

THE SKIAGRAPHY OF THE
ACCESSORY NASAL SINUSES

A. Logan Turner
& W. G. Porter

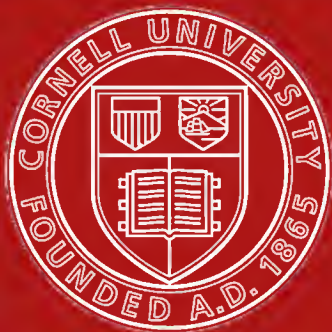
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THE SKIAGRAPHY OF THE ACCESSORY
NASAL SINUSES



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FRONTISPIECE.

Antero-posterior skiagram of human skull.

THE SKIAGRAPHY OF THE ACCESSORY NASAL SINUSES

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BY
TWO OF HIS PUPILS

PREFACE

DURING the last four years we have employed the X-rays as a routine method of examination in our cases of accessory sinus disease. As we have undoubtedly obtained much useful information and practical assistance in our work from their use, we wish to record our experience in this volume and place it at the disposal of others who are interested in the same branch of surgery. We hope that it may prove useful to them.

We are engaged upon similar work in connection with the mastoid region of the skull, and it is our intention to publish it at some future time.

We desire to express our thanks to Professor Arthur Robinson, of the University of Edinburgh, for the loan of some of the skulls which have been reproduced.

A. LOGAN TURNER.

W. G. PORTER.

EDINBURGH, 1912.

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INTRODUCTION

WHILE no one will dispute the statement that our knowledge of the etiology, diagnosis and treatment of the inflammatory affections of the accessory nasal sinuses has greatly increased during the last twenty years, the fact remains that upon all these points further information is still required. Difficulties in accurate diagnosis by means of the ordinary clinical methods at our disposal are still frequently met with, while considerable uncertainty is sometimes experienced in dealing with the sinuses surgically owing to an imperfect acquaintance with their actual size and with the exact anatomical relations of one cavity with another.

It is a matter of common experience that cases of frontal, ethmoidal, sphenoidal and even of maxillary sinus suppuration are from time to time met with in which the surgeon is unable to make up his mind regarding the condition of the sinus without first carrying out some small intra-nasal surgical procedure. It may be necessary to remove the middle turbinated bone, to catheterise the frontal sinus, to open the ethmoidal and sphenoidal cavities, and to puncture and wash out the antrum for diagnostic purposes alone. If it were possible to arrive at a correct diagnosis in doubtful cases without such preliminary investigation it would prove, in some cases at any rate, advantageous to the patient. If, at the same time, the surgeon could obtain information regarding the size and relations of the suspected cavity the gain would be a twofold one in the event of operative interference being carried out.

With the discovery in 1895 of the X-rays by Professor Röntgen, and their application to medicine and surgery, it was natural that attempts should be made to utilise them in the domain of nasal surgery. In 1897 Scheier published the results of his attempts to facilitate the diagnosis of accessory sinus suppuration with the aid of the X-rays (*Arch. f. Laryngol.*, Bd. vi., Berlin). The results, however, were not satisfactory, partly on account

of the defective character of the apparatus at that time and partly from the fact that an exposure of ten to fifteen minutes was required when the rays were passed through the antero-posterior diameter of the head. In this country Macintyre was the first to demonstrate the practical application of the rays in the diagnosis of sinus disease, and in some cases he found them of undoubted value for this purpose where other methods had failed (*British Lar. and Otol. Assoc.*, 1900). The publications of Winckler in 1901 increased our knowledge of the usefulness of the rays in the study of rhinology (*Fortschr. auf dem Gebiet. der Röntgenstrahl.*, Bd. v. and vi.). It was not, however, until 1903, with the appearance of Gustav Killian's plates depicting the accessory sinuses of the nose, that a more general interest was taken in the application of the X-rays to nasal surgery (*Die Nebenhöhlen der Nase auf 15 Tafeln dargestellt.*, Jena, 1903). Amongst those who have contributed in more recent years to the literature of the subject, and who have undoubtedly improved the technic and assisted in the interpretation of the X-ray plates, must be mentioned in addition to Killian the names of Goldmann, Coakley and Caldwell, Mosher, Albrecht, Burger, Pfeiffer and Haike. We desire to draw special attention to the valuable atlas of Kuttner, published in 1908, dealing with the inflammatory affections of the sinuses. In the same year Johnson Symington and Rankin produced an atlas of skiagrams illustrating the development of the teeth and at the same time demonstrating in a striking way the relation of these organs to the maxillary sinus. In America, Joseph C. Beck has devoted considerable attention to the study of the radiography both of the mastoid region and of the nasal accessory sinuses, and his work has recently been summarised in the form of an atlas, which was published in 1910.

Impressed with the value of this method of investigation, we turned our attention to a study of the subject, and installed the necessary apparatus in the Ear and Throat Department of the Royal Infirmary, Edinburgh, in 1907. The pictures now reproduced illustrate part of the work which has been carried out in the Department. Some of the plates have been exhibited from time to time at the annual and branch meetings of the British Medical Association. We have systematically used the X-rays in connection with the diagnosis and treatment of affections of the nasal sinuses during the last four years,

and more recently also in relation to the mastoid region of the skull. We have no hesitation in saying that in accessory sinus work we have learnt to appreciate the assistance which radiography undoubtedly gives. The object which we mainly have in view in this volume is to demonstrate this fact, and to endeavour to simplify the interpretation of what must be regarded by many as the somewhat complicated skiagram of the head. The original photographs have been reproduced by the half-tone process.

THE APPARATUS AND TECHNIC

In the skiagraphy of the head a good apparatus and careful technic is very essential. The instrument which we have employed is "The Rotax," supplied by the Sanitas Electrical Company of Berlin. The photographic apparatus consists of a "safety box" impenetrable to the rays and provided at one end with a compression tube into which an iris-diaphragm is fitted. The box is attached to a stand in such a way that it can be tilted as desired in order to photograph the patient either in the sitting or recumbent posture. Moderately hard tubes were, as a rule, used, giving a spark gap of 15 cm., while a primary current of 5 ampères was employed. The X-ray tube is fixed inside the "safety box," with the anti-cathode placed as nearly as possible opposite to the central point of the iris-diaphragm, the diameter of which, as a rule, was about 10 cm. The distance from the anti-cathode to the distal margin of the compression tube must be a constant one; in our work the distance was $9\frac{1}{2}$ inches.

With very few exceptions the patients were placed in the sitting posture in preference to the recumbent, as we found that in the former the posing could be more correctly judged. In the case of a male patient the coat, collar and tie should be removed in order to give freer play to the head, while a woman should remove all hair-pins and hair ornaments, and loosen the neck of her dress. In the photography of the nasal and accessory cavities two views of the head may be taken, the antero-posterior or sagittal, and the lateral or profile view. Vertex pictures have recently been demonstrated by Pfeiffer with the object of depicting the two sphenoidal sinuses side by side (*Arch. f. Laryngol.*, Bd. xxiii., 1910). Great care must be exercised not only in accurately adjusting the head in front of the compression tube but also in poising the head upon

the spinal column. If an antero-posterior picture is desired the occipital region of the skull is placed against the compression tube in such a way that the external occipital protuberance is opposite the centre point of the iris-diaphragm, so that the rays fall perpendicularly upon it. On account of the difficulty in judging of the accuracy of this when the back of the head is against the tube we have made use of the zygomatic process as a guide to the correct position of the head upon the spinal column; in other words, the zygomatic process should occupy approximately a horizontal plane opposite the centre of the rim of the compressor. The chin of the patient should be thrust very slightly forwards. The plate-holder is now brought in contact with the face, touching the forehead and the tip of the nose, and fixed in that position by means of an elastic band. The sensitised side of the negative is in every instance placed next to the patient. When a lateral or profile view is required the sitting posture has usually been adopted. The compression tube is placed against one cheek, the plate-holder being fixed against the other. In adjusting the head to the correct position care should be taken that the centre of the rays passes through a line which bisects the zygoma.

We have found some difficulty in the application of the tube to the vertex, as suggested by Pfeiffer for the purpose of radiographing the sphenoidal sinuses. The plate-holder is laid flat upon a table, and the patient, sitting on a low stool, is brought close up to the edge of the table. His chin is then thrust forwards as far as possible over the plate, great care being taken at the same time that the base of the skull maintains the horizontal and remains parallel with the plate. The compression tube is then inverted upon the vertex of the head in such a position that the axis of the rays passes through the skull in the vertical plane at a point 2 cm. anterior to the central point of the external auditory meatus. As an alternative procedure to this the patient may be laid upon his back with the head hanging over the end of the table, and with its vertex resting upon the plate-holder, which is placed upon a stool. The compression tube is adjusted against the under surface of the extended chin, the same care being taken as before to direct the rays through the same vertical plane.

For the purpose of obtaining stereoscopic views a skiafix apparatus is used, so that the head may thus remain quite stationary while the two pictures

are taken. The same apparatus is also useful in dealing with young children when there is a risk of movement. The method of procedure in stereoscopy is as follows:—The patient and the compression tube are in the first instance arranged in the same way as has been described in connection with the taking of a single skiagram. The compression tube is then moved one inch to the right, and the first exposure is made. The plate-holder is removed and a fresh plate is inserted into it and again laid against the head. The compression tube is now moved two inches to the left, and the second exposure is made. In other words, each exposure is carried out with the rays passing through a point one inch to either side of the point through which they pass when a single skiagram is being taken. Special apparatus for the accurate adjustment of the compression tube in taking the two positions may be attached to the photographic machine.

The duration of the exposure is a matter of considerable importance not only to the patient but also as regards the life of the X-ray tube. It must be borne in mind that in dealing with the head a longer exposure is required than is the case with the limbs or the thorax. The duration of the exposure of the macerated skull is of course less than that of the head. In our earlier work it was found necessary in the case of antero-posterior exposures to give 80 to 100 seconds, and in the lateral positions 45 to 60 seconds. With the introduction of the "Sunig" screen, however, a considerable reduction in time became possible; thus in the antero-posterior views an exposure of 10 to 15 seconds, and in the lateral views 8 to 10 seconds only are necessary, the variations in time suggested by these figures depending upon the sex and age of the individual. Good skiagrams may be obtained by instantaneous exposures, but we have not practised this method. When the screen is employed its sensitive surface is placed in contact with the sensitised surface of the negative within the same plate-holder, care being taken that there should be no dust between the surfaces, so as to avoid the production of "pin-holes." If the sensitive surfaces of the screen and the negative are not placed in direct apposition a blurring of the picture results: the screen must be put between the patient and the sensitive plate in order to prevent the skiagram becoming reversed in the positive. It will be readily understood that a mistake of this kind might lead to errors in

diagnosis when we are examining the positive in a case of suspected unilateral sinus disease. The mistake was accidentally made in the case of the patient photographed upon Plate XXXVIII.

The X-ray negatives are developed in the same way as ordinary photographic plates. We have used rodinal as a developer, as it appears to be of more value than other forms of developer when the exposure has not been altogether satisfactory.

THE INTERPRETATION OF THE SKIAGRAM OF THE NASAL AND ACCESSORY NASAL CAVITIES

A. THE ANTERO-POSTERIOR SKIAGRAM OF THE SKULL

When we study a skiagram of any part of the human body it is necessary to bear in mind that structures of varying density and lying upon different planes are seen as if upon one plane when portrayed in the picture before us; whether studied in the negative or in the positive a somewhat complex picture is presented. It is necessary, therefore, to devote much careful study to the interpretation of the normal appearances presented not only by the macerated bones but in the living subject. A better knowledge of the details is obtained by inspection of the skull in the first instance, because with the soft parts superadded clearness and definition are to a considerable extent reduced. Whether we have to deal with an antero-posterior or with a lateral view of the skull we must differentiate between the contour lines and shadows representing the parts nearest the X-ray tube and those which are in immediate apposition to the photographic plate. The latter are the more clearly depicted, so that in an antero-posterior view we have mainly a representation of the facial skeleton. There is no doubt that in the stereoscopic picture we have a better means of instructing ourselves than in the single skiagram, but when we have once mastered the details it is no longer necessary to employ stereoscopy in every case. For that reason we have only reproduced a few stereoscopic plates of the skull. An outline key has been introduced along with certain of the plates in order to facilitate their interpretation and supplement the verbal description.

On Plate I. we have an antero-posterior view of the adult skull without the lower jaw bone. In the application of the X-rays to accessory sinus disease the antero-posterior picture must be regarded as the one which is of most service for diagnostic purposes. It must be borne in mind for descriptive purposes that the skiagram represents the subject as facing the observer. Conspicuous in the centre of the skiagram and readily defined by reason of its dark outline is the pyriform anterior aperture of the nasal cavities. As the nasal bones offer little obstruction to the rays they present no very obvious shadow. The osseous nasal septum, somewhat deflected to the left in its anterior and lower part, forms a vertical line subdividing the nasal cavities more or less equally. Lying in the same vertical plane as the septum but at a higher level and within the cranium is the crista galli. This structure is slightly expanded, and the clearer area in its centre represents the cancellous bone which lies within it. In the skiagrams of one or two heads which we have taken the appearance of the crista galli suggested the presence of an air space within it. In a dissected specimen in our collection an air cell in the crista galli communicates through a small aperture with an anterior ethmoidal cell lying in the floor of the left frontal sinus. As this anatomical connection does therefore occur, it is obvious that the diagnosis of an air space in the crista galli by means of the X-rays may be of clinical importance in cases of ethmoidal suppuration.

The posterior free margin of the nasal septum is seen as a fainter line in the mesial plane, and passing upwards and outwards from its superior extremity on each side the outline of the roof of the two choanæ or posterior nares can be recognised. Similarly, at its inferior extremity the lower margins of the same apertures formed by the posterior margins of the hard palate are visible. The projecting inferior turbinated bone can be recognised upon the lower part of each lateral wall of the nasal cavity.

The Sphenoidal Sinuses.—Within the upper and narrower part of the pyriform aperture and above the choanal margins lies the body of the sphenoid bone containing the two sphenoidal sinuses. It is impossible to say whether the dark vertical line of the nasal septum in this region also indicates the bony partition between the two sphenoidal cavities, but in all

probability it does so. A small oval clearer area to the left of the mesial plane maps out the position of the left ostium sphenoidale. On Plate IV. the situation of the two sinuses has been more clearly defined by filling them with bismuth paste. It is interesting to observe that the cavities extend above the plane of the transverse, curvilinear line, to which reference will presently be made and which represents the lesser wings of the sphenoid bone. This is explained by the anatomical fact that the upper surface of the body of the sphenoid, which forms the roof of the sphenoidal sinus, lies on a higher plane than the lesser wings. Plate V. has been similarly treated in order to give a profile view of the sphenoidal sinuses; their relation to the sella turcica is thus seen. On Plate IV. a portion of the ethmoidal cell area is visible external to the sphenoidal area on each side, while on Plate V. it forms an anterior relation to the latter. On Plate VI. a vertical skiagram has been taken, and the sphenoidal sinuses are viewed from the basal aspect of the skull in relation to the posterior edge of the hard palate; the basi-occipital bone and foramen magnum lie posteriorly.

A striking feature in every antero-posterior view of the skull, and visible to a considerably lesser extent in the living subject, is the slightly curved, dark, transverse line which crosses the apex of the pyriform aperture (Plate I.). It traverses the upper third of the orbital cavities and passes externally on to each lateral aspect of the skull. The structures thus defined are the lesser wings of the sphenoid bone and the posterior free edge of the orbital plate of the frontal bone. The importance of this line becomes obvious when we remember that it indicates the plane of the posterior edge of the floor of the anterior cranial fossa. It must be borne in mind, however, that the position of the line in the skiagram will vary with any slight alteration in the poise of the head. When the head is correctly placed the line should fall within the upper third of the orbital cavities. A faulty position is well seen on Plate VIII., where in consequence of the upward tilting of the facial skeleton the line of the lesser sphenoid wings bisects the orbital cavities and the nasal cavities are considerably distorted.

The Orbit.—The orbits are well defined, the superior and inferior orbital margins being strongly marked. The external margin of each

cavity is strengthened by the broad shadow which is produced by the frontal process of the malar bone as it ascends to articulate with the external angular process of the frontal bone. The inner margin of the orbit is less well defined owing in part to the fact that the X-rays traverse the air spaces of the ethmoidal bone and thus make this region brighter. The thickened posterior edge of the frontal process of the superior maxilla, however, forms a slightly curved dark line which completes the internal orbital margin. Sometimes a narrow zone of light, brighter than the surrounding ethmoidal region, indicates the position of the groove for the lachrymal sac. At the apex of the orbit the sphenoidal fissure is clearly defined, while immediately below it the foramen rotundum is seen through the orbital floor. The optic foramen may be observed upon the left side immediately above the inner end of the sphenoidal fissure (Plate I).

The Ethmoidal Air Cells.—These cells occupy the inner wall of the orbit. Within the brighter area which represents them in that situation three dark vertical lines are seen; these are most evident on the left side on Plate I. The most anterior probably represents the thickened edge of the frontal process of the superior maxilla, the middle one the ridge upon the lachrymal bone, while the most posterior represents the articulation of the os planum of the ethmoid with the sphenoid bone. Upon both sides, especially on the left, however, the cells are seen extending downwards to the upper inner angle of the maxillary sinus with which they are contiguous. Superiorly and anteriorly the ethmoidal cell area is seen in relation to the floor of the frontal sinus.

In a considerable proportion of skulls the ethmoidal cells extend into the roof of the orbit within the orbital plate of the frontal bone. Plate IX. has been introduced in order to illustrate this point. On the left side of the picture the anterior wall of the frontal sinus has been removed, and along with it the floor of a large ethmoidal extension into the orbital roof. The dark line which crosses the cavity of the orbit obliquely from within outwards indicates the extent of the ethmoidal air space in this case. It is evident that a similar condition exists on the right side of the skull.

The Frontal Sinuses.—The frontal sinuses are clearly defined on Plate I. above the nasal cavities and the inner third of the supra-orbital margins. They

are comparatively small, asymmetrical cavities with the inter-sinus septum oblique and deviated to the right. The dark vertical line continued upwards from the crista galli and traversing the left sinus is the thick crest of bone which gives attachment to the falx cerebri upon the cerebral aspect of the frontal bone. The outline of both sinuses presents a clearly marked definite margin devoid of any irregularity. The varied contour of the frontal sinus, however, is well illustrated in the different plates both of the skull and of the living subject. The irregular outline is well seen on Plates VIII., XXXIV., and XXXV., the small "bays" with their intervening septa being very obvious on Plates XXXIV. and XXXV.

Within the area of both frontal sinuses on Plate IX. and in the lower part of the cavities a few wavy, short, dark lines are visible. At first we experienced considerable difficulty in interpreting the meaning of these lines. We are of the opinion that they represent some of the irregular bony elevations which are present upon the cranial surface of the orbital plate of the frontal bone. A slight increase in the thickness of the walls of the sinus produces a corresponding increase in the shadow of the skiagram.

Killian has drawn special attention to a clearer area which frequently presents itself in the lower part of the frontal sinus, immediately above the supra-orbital margin. This area is usually demarcated above by a dark line, and is very well brought out in the skull figured in the frontispiece and in the head on Plate XXIII. and in the right sinus on Plate XXVI., though it is seen to a lesser degree in other plates in the series. When present it indicates the existence of an orbital extension of the frontal sinus. The density of the shadow in a healthy air sinus depends mainly upon the depth of the air space through which the X-rays pass. If the antero-posterior diameter of the orbital extension of a normal frontal sinus exceed the diameter of its vertical portion the shadow presented by the former will be less dense than that of the latter; the deeper the orbital extension, therefore, the more marked is the contrast between the shadows of the vertical and horizontal parts of the sinus.

The Maxillary Sinuses.—The maxillary sinuses are well delineated as pyramidal-shaped cavities beneath the orbits. The nasal wall of each sinus is seen extending from the anterior to the posterior nares. The roof corresponds

to the floor of the orbit; the infra-orbital margin can be traced as a dark line continuous at its inner end with the margin of the anterior nares, while on a somewhat higher plane the posterior edge of the roof is seen to be continuous with the line representing the external margin of the posterior nares. This is best illustrated on the right side of the skiagram on Plate I. In the roof itself and close to the postero-internal angle of the antrum is the foramen rotundum. The external wall of the sinus in its upper half is almost completely concealed from view, in part by the intervention of the deep shadow of the petrous temporal bone lying upon a deeper plane and partly by the denser malar bone lying anteriorly to it. The floor of the maxillary sinus or the alveolar recess is very shallow in this skull, and lies almost on the same plane as the floor of the nasal cavities. The deep alveolar recess, which is more commonly met with, is well seen on Plates IX., XXVIII., and XXXIV., where the floor of the antrum lies on a lower level than the nasal floor. An extension of the floor of the sinus beneath the nasal cavity into the palatal process of the superior maxillary bone—the palatal recess—is sometimes met with, and is well shown on Plate XXXV.

In studying the cavity of the maxillary antrum in the skull (Plate I.) we find variations in the density of its shadow in different areas. This is due to the fact that shadows produced by certain structures lying posterior to the sinus may fall within the cavity. Thus the petrous portion of the temporal bone forms a dense shadow across the upper half of each sinus. Killian has drawn special attention to this, and points out that the relation of the petrous temporal to the maxillary sinus depends upon the position of the head and its relation to the axis of the X-rays as they fall upon the occiput. Care should be taken to bring these shadows as far as possible within the region of the orbits, where they will not interfere with the interpretation of the true shadow of the antra. This is attained by causing the rays to fall perpendicularly over the external occipital protuberance. If the shadow of the petrous temporal falls within the orbit, the deep shadow of the inferior part of the occipital bone will occupy the lower part of the antral cavity. On Plate I. the shadow of the occipital bone is lying across the shadow cast by the teeth of the upper jaw. The external pterygoid process of the sphenoid bone throws a vertical shadow within the inner half of the

antrum, which is more readily seen in the right sinus on Plate I. As already indicated, the malar bone assists in obscuring the antral cavity at its superior external angle.

When an antero-posterior skiagram of the head of the living subject is studied, another shadow falls within the lower and mesial portion of each maxillary sinus. Killian has satisfied himself that this is produced by the cervical vertebral column.

B. THE ANTERO-POSTERIOR SKIAGRAM OF THE HEAD IN THE LIVING PERSON

If the skiagram of the skull just described in detail (Plate I.) be compared with any of the antero-posterior pictures of the living subject it is at once obvious that with the addition of the soft parts a good deal of the clearness of detail is lost. At first sight many of these pictures raise a feeling of disappointment, and produce the impression that little can be learnt from them. With the knowledge previously gained from a study of the skull, however, and with closer observation, it becomes evident that this is not the case unless a really poor skiagram has been obtained; under such circumstances a second one should be taken. Even the best results may often leave something to be desired. It is more difficult to obtain good results with the head than with any other part of the body. Plate X. represents the head of an adult in which there was no pathological condition present, consequently it may be taken as a good illustration of the usual appearances presented in the skiagram of the normal sinuses. The nasal septum is a prominent landmark in this as in the majority of the heads in the series, and is more strongly marked than in the macerated skull. The same remark applies to the inferior turbinated bodies, their mucous covering causing a broader, deeper shadow than the bony plate. The middle turbinated bodies upon a higher plane are not always well defined, but they may be seen in some of the plates. The narrow bright area immediately adjacent to the highest part of the septum upon each side is probably produced by the passage of the X-rays through the sphenoidal air sinuses.

The transverse curvilinear line representing the lesser wings of the sphenoid is faintly visible as it crosses the anterior nasal aperture, and lies within the upper third of the orbital cavities.

A striking feature on Plate X. is the clear area upon the inner aspect of each orbit due to the presence of the ethmoidal air cells. As we shall indicate later, variations in the density of the ethmoidal shadow are of very considerable significance in the detection of disease in this area.

The frontal sinuses in this case are very small cavities ; both present an almost equal degree of density of shadow, but their outlines are not clearly defined. Variations in the density of the shadow in healthy frontal sinuses depend upon the antero-posterior depth of the cavities ; that is to say, upon the diameter of the air space traversed by the rays. If the sinus on one side is slightly shallower than that upon the other some inequality between the two sides will be recognised. It must not be forgotten, also, that in a comparison of the X-ray shadow upon the two sides of the face in normal individuals some asymmetry in the thickness of the facial bones must be taken into account. The appearance presented by the outline of the frontal sinus is of great clinical importance. In the case of the healthy sinus the outline, even though in one instance it may be faint, is nevertheless, as a rule, clearly defined, whereas when the lining mucous membrane is inflamed or thickened the outline of the cavity becomes blurred and hazy.

The shadow of the maxillary sinuses in the living subject also presents variations in density. We have already referred in our description of the skull to the various causes which may lead to changes in the shadow of the healthy maxillary sinus, and it is unnecessary to repeat them. On Plate X. the shadow of the petrous temporal bone is seen on the plane of the roof of the antrum. The right cavity is larger than the left, and has an alveolar recess, so that its floor is on a plane below the level of the floor of the nasal cavity. On the left side the alveolar process consists of dense bone, and the floor of the antrum is slightly higher than the nasal floor. The outline and arch of the hard palate are well delineated by the dense shadow of an upper denture. On Plate XII. a stereoscopic view of a head has been reproduced.

C. THE PROFILE SKIAGRAM OF THE SKULL

Though the lateral or profile view of the head is not of so much clinical value in the study of the accessory sinuses as the antero-posterior skiagram, nevertheless it furnishes information on certain points which cannot be other-

wise ascertained. Plate XIII. represents the profile of the left side of an adult skull, while on Plate XVI. we have figured the right side of the face of an adult. A key has been provided to each of the plates. The primary difficulty in connection with the interpretation of the lateral skiagram is due to the fact that the sinuses of one side are superimposed upon those of the other. While in some instances the outlines of the right and left cavities correspond, in other cases they do not do so, and it may be difficult, if not impossible, to say whether we are tracing the outline of the sinus upon the right or upon the left side of the face. By means of the stereoscopic picture, however, our knowledge of the relationship of the parts on the two sides is greatly increased, and what is difficult to interpret in the ordinary skiagram will at once become clear. Plate XV. is a stereoscopic profile view of the skull.

If we proceed to examine in detail the skull figured on Plate XIII. we have no difficulty in defining the facial contour. The frontal region is marked by prominent supra-ciliary ridges; underneath them the nasal bones with the subjacent anterior nasal aperture terminating below in the prominence of the anterior nasal spine are clearly shown. Below the spine the premaxillary portion of the upper jaw bones inclines downwards and forwards, and the shadow of the projecting right lateral incisor tooth is seen at its lower end slightly overlapping the corresponding tooth in the lower jaw. Both the right and left halves of the lower jaw are seen, the left body and ramus presenting a darker and more clearly defined shadow than the right. Behind the rami are the shadows of the right and left mastoid processes.

The Frontal Sinuses.—The interpretation of this region may, in some cases at any rate, prove by no means easy, the two frontal cavities being often of unequal size. Certain dark lines running antero-posteriorly in the floor of the anterior cranial fossa strike the eye. A glance at the interior of the base of a skull reveals the fact that each lateral portion of the anterior fossa—the orbital plate—is slightly dome-shaped, and is not a plane surface. Both the highest and the lowest part of each orbital plate may be represented in the lateral skiagram by antero-posterior lines. Consequently we may have as many as four of these extending somewhat obliquely from before backwards. On the other hand, owing to the fact that the summits

or the lowest parts of the floor on the two sides may occupy corresponding levels, the lines may blend in the skiagram, so that their number is reduced. If Plates XIII. and XVI. be compared it will be seen that while three lines can be differentiated in the former—that is, in the skull—only two are obvious in the living head on Plate XVI. In the negative of the skull, however, four lines can be made out on account of the greater clearness in detail (Plate XIV.). A glance at the key tracing of Plate XIII. will show the reader the interpretation which has been put upon these lines.

When the frontal sinus has a horizontal extension into the roof of the orbit, or, in other words, into the floor of the anterior fossa of the skull, it necessarily follows that the lines which we have just described will also indicate the upper and lower boundaries, *i.e.* the roof and floor of the orbital extension. This is evident when we attempt to map out the two frontal sinuses on Plate XIV., each of which has a well-marked orbital extension. The left or near frontal sinus, both in its vertical and horizontal portions, is indicated on the key by the dark lines marked with the letter B, while the letter A indicates the outlines of the corresponding parts of the right or more distant sinus. It will be observed that the orbital extension of the left sinus reaches almost to the apex of the orbit, while that of the right sinus does not extend so far backwards. We were able to satisfy ourselves of the correctness of these points by dissection. On a plane corresponding to the fronto-nasal suture in front and to the anterior clinoid process posteriorly the position of the cribriform plate of the ethmoid bone is faintly indicated.

The Ethmoidal Cells.—In the anterior part of the ethmoidal region the external margins of the orbits, strengthened by the frontal process of the malar bone, are outlined. They interfere to some extent with the interpretation of this region. The anterior ethmoidal cells are situated within the cavity of the orbits, but it is impossible to differentiate their outlines in this picture. In the negative, however (Plate XIV.), the cells can be to some extent defined. The posterior ethmoidal region, on the other hand, lying behind the orbital margin, presents better definition.

The Sphenoidal Sinuses.—Beneath the sella turcica and in the body of

the sphenoid bone the right and left sphenoidal cavities, evidently unequal in size, are well seen, one sinus extending somewhat further forwards than the other. Beneath the posterior part of the sella turcica and the posterior clinoid process the cancellous structure of the sphenoid bone is evident.

The Maxillary Sinuses.—The two maxillary sinuses lie beneath the orbits, between them and the dark lines which indicate the position of the hard palate. The interpretation of these cavities is considerably interfered with by the dense shadows of the malar bones; the narrower V-shaped shadow represents the left malar, while the broader and more anterior shadow is that of the malar bone of the right side (Plate XIII.).

D. THE PROFILE SKIAGRAM IN THE LIVING PERSON

The head of a normal adult is represented upon Plate XVI. with the right side of the face towards us. It is unnecessary to repeat what has already been detailed in the description of the skull. One or two points, however, require special reference. Two frontal sinuses are seen in the vertical portion of the frontal bone, but there is no evidence that either has an orbital extension. In consequence of this the dark lines in the base of the anterior cranial fossa have a different arrangement from that seen in the skull. The dark broad line extending backwards to the anterior clinoid process is formed by the blending of the highest parts of the floor of the fossa on each side, while at a lower level a line of lesser density indicates the position of the lowest parts of each fossa.

The sphenoidal sinuses are very large, but unequal in size; the anterior wall of one of the cavities is well defined, and although that of the other cavity is less clearly indicated, it can nevertheless be traced upwards as it lies a short distance behind the former. The whole of the body of the sphenoid bone is occupied by the sinuses.

The maxillary sinuses, unlike those in the profile view of the skull, are not obscured by the malar bones, though the triangular outline of the right malar can be defined. It is interesting to note that the outlines of both the sinuses can be followed, but we do not feel able to express an opinion as to which is the right or the left cavity.

THE VALUE OF THE SKIAGRAM IN ANATOMY AND SURGERY

No one will now dispute the fact that in the skiagraphy of the head the anatomist and the surgeon possess a valuable means of studying the nasal and accessory nasal cavities. Doubtless the anthropologist too will derive useful information from a comparative study of crania by this method. It is not our intention, however, to do more than emphasise in the first instance the anatomical points which have a direct bearing upon the surgery of the sinuses and then to illustrate the value of the skiagram in the detection of diseased conditions.

Anatomical Considerations.—Under this heading we propose to deal first with the development of the sinuses in children, and secondly with their anatomical configuration and relations in the adult.

1. DEVELOPMENT OF THE SINUSES

It is self-evident that a knowledge of the early development and growth of the various accessory cavities must undoubtedly be of value to the clinician. From time to time in the course of his work he is faced with the problem as to whether a sinus actually exists in the child whom he is examining, or if present, as to its probable size. It is true that these points are dealt with in the various text-books of anatomy and in monographs upon diseases of the nose and throat. As the statements made therein, like the sinuses themselves, are subject to considerable variation, it is often difficult for the surgeon to accurately estimate their value in any given case. If a skiagram of the head be taken, however, as a supplementary means of diagnosis, the difficulties will be overcome.

It is probably in connection with the *frontal sinus* that the question most frequently arises as to the age at which the sinus is first found as a distinct cavity in the frontal bone. It is generally held that the sinus commences to develop at the end of the first or at the beginning of the second year of life, as an upward extension of the ethmoidal cell labyrinth or as a recess developing upwards from the anterior end of the middle meatus. Onodi's recent researches, however, appear to show (*Die Nebenhöhlen der Nase beim Kinde*, 1911) that development actually commences

at birth. It is sometimes difficult to determine in very young children whether the air cavity represented in the skiagram is a frontal sinus or an anterior ethmoidal cell. If, however, skiagrams are taken at different periods of time in the same children, as has been done by Haike (*Arch. f. Laryngol.*, Bd. xxiii., Ht. 2, Berlin, 1910), the commencement and growth of the frontal sinus may thus be determined. Killian (*Zeitschr. f. Ohrenhk.*, 1908) opened a diseased frontal sinus in a child aged one year and three months; Wertheim (*Arch. f. Laryngol.*, Bd. xi.) found at a post-mortem examination a well-developed frontal sinus in a child aged two years and two months; Haike radiographed a girl aged two, and failed to detect any evidence of a sinus, but a second skiagram, taken when she was two years and nine months old, revealed a right frontal sinus; Edmund Meyer (*Berl. klin. Woch.*, 1905) has published the case of a child aged three upon whom he operated and found pus in the frontal sinus; Onodi (*Die Nebenhöhlen der Nase beim Kinde*, 1911) figures the skiagram of the skull of a child aged three and a half in which both frontal sinuses are present, extending for a distance of 6 mm. both in the vertical and horizontal directions; Haike has in two instances observed small frontal sinuses in children of three and a half years by means of the skiagram.

Our own observations upon very young children have been somewhat interfered with on account of their timidity while being photographed. We have introduced on Plate XIX. the skull of a child between the age of three and four. In contradistinction to the skull figured by Onodi at three and a half years, it presents no evidence of a frontal sinus. Air spaces are seen in the ethmoidal region on each side, but they are distinctly demarcated from the frontal bone. On the other hand, on Plate XX., which represents the head of a child aged five, two small frontal cavities are seen in an early stage of development, that upon the left side being slightly the larger. Here the air spaces occupy the lowest part of the frontal bone. Haike has drawn attention to a possible source of error in connection with the diagnosis of a frontal sinus by skiagraphy in very young children. In rare instances the frontal diploë may be of such a loose texture (*weitmaschig*) that the shadow which they present resembles that of a distinct cavity. In our description of the crista galli on Plate I. we drew attention to the loose

cancellous texture of the bone, and pointed out how it might give the impression that an air cell was contained within it.

On Plate XXI. the head of another child aged five is shown where the frontal sinuses have attained a very considerable development. On Plate XXII. the head of a child aged seven shows the left frontal sinus extending outwards above the supra-orbital margin. There is no evidence of an air cavity upon the right side.

Unless a very large number of skiagrams are made from children under seven years of age no valuable deductions can be drawn as to the relative frequency with which frontal sinuses exist between the tables of the frontal bone in the early years of life. If we regard as exceptional the occurrence of sinuses before or at five years of age we may legitimately say that at and after the seventh and eighth year the presence of a sinus is the rule rather than the exception. At this age the cavity may assume very considerable proportions.

The Maxillary Sinus.—As the maxillary sinuses are present at birth they naturally become cavities of considerable size and of clinical importance at an earlier age than the frontal sinuses. At birth the sinus forms a slit-like indentation upon the outer wall of the nasal chamber, with a transverse diameter of 2 mm., a vertical diameter of 3 mm., and an antero-posterior or sagittal diameter of 7 mm. For the purpose of studying the growth of the sinus in the earlier years of life we have introduced the skiagrams of two skulls, one of a child aged one and another of a child between three and four years of age (Plates XVIII. and XIX.) On Plate XVIII. the maxillary sinuses are seen as small cavities beneath the most internal part of the infra-orbital margin. The infra-orbital foramen is seen on each side, just external to the outline of the sinus. The body of the upper jaw bone, owing to its cancellous texture, offers little obstruction to the passage of the rays. The cavity of the sinus, therefore, is distinguished from it mainly by the darker line of demarcation. This is better seen upon the left side of the skull. On Plate XIX., the skull of a child aged three to four, well-formed triangular sinuses are seen. Even at this age, however, the cavities do not extend beyond the infra-orbital foramen. The dense shadows of the petrous temporal bone and of the un-erupted permanent

teeth conceal the cancellous texture of the rest of the body of the superior maxilla. On Plate XX. we have the head of a child aged five showing well-developed maxillary sinuses extending outwards to the junction of the middle and outer thirds of the infra orbital margins, and now reaching below to the plane of the floor of the nasal cavities. The dense shadows of the permanent teeth are seen immediately below each sinus.

Haike gives the following measurements for the maxillary sinus in young skulls:—

Age.	Transverse.	Antero-Posterior.
1½ years	4.5 mm.	20 mm.
2 „	8 „	25 „
5 „	16 „	25 „

At the age of seven the transverse diameter of the maxillary sinus has increased, and the cavity now extends outwards to a plane midway between the infra-orbital canal and the malar or zygomatic process of the superior maxilla. At the ninth year the cavity exists in the malar process of the bone, but owing to the dense shadow of the malar bone this extension of the cavity is not visible in the skiagram. The age at which the alveolar recess develops is of clinical importance in connection with any operative procedure upon the sinus by way of the nasal cavity. Haike points out that we cannot determine this point by a study of an antero-posterior picture because the second and third molar teeth throw a dense shadow upon the floor of the sinus. On the other hand, if a profile view of the child's face be taken this point can be demonstrated. He illustrates the presence of this recess in the anterior part of the floor of the antrum in a child aged eight by means of a lateral skiagram of the head. The alveolar recess, however, is not completely developed until all the permanent teeth have erupted.

The Ethmoidal Air Cells.—The ethmoidal cells commence to develop during fetal life. It is difficult even in the skiagram of the macerated skull to differentiate the shadow cast by these cells at birth or even at the age of one year to judge from the appearances seen on Plates XVII. and XVIII. As the cells are small, and as they are still surrounded by the osseous structure of the lateral mass of the ethmoid in which they are developed, the shadow of the ethmoidal region closely resembles that of the other facial bones in the immediate neighbourhood. With the growth of the skull, however, and the

further development of the air spaces in the ethmoid bone, we are able to observe the gradual broadening of the ethmoidal region, while the lighter shadow produced by the enlarging air spaces becomes progressively more obvious. If Plates XIX., XX., and XXI. are compared with Plates XVII. and XVIII. the development of the ethmoidal air cells can be observed.

The Sphenoidal Sinus.—Various statements have been made as to the period at which the sphenoidal sinus commences to develop. According to Onodi the sinus at birth is the size of a pin's head, while during the second and third years of life it has attained the size of a pea (Zuckerkanndl). Onodi gives the measurements of the sphenoidal sinus during the first year of life, and states that its height varies from 1 to 9 mm., its depth or antero-posterior diameter from 1 to 5 mm., and its breadth from 1 to 6 mm. In the early stages of its development no information regarding its size can be obtained from the skiagram because the bone in which it develops throws too dense a shadow. Haike first differentiated the sinus in the skiagram at the age of three and a half years, the cavity presenting a brighter area within the dark shadow of the body of the sphenoid. Profile views of the head are necessary for the study of the growth of this cavity. Onodi's measurements of the sinus in a child aged three and a half are :—Height, from $4\frac{1}{2}$ to 6 mm. ; depth, $3\frac{1}{2}$ to 5 mm. ; breadth, 7 mm. The same writer saw in a child aged six a sphenoidal sinus the size of a bean. It is necessary, however, in studying skiagrams of this region in very young people to bear in mind that we may be deceived by the lighter shadow presented by the cancellous tissue of the body of the sphenoid bone.

2. THE ANATOMICAL CONFIGURATION AND RELATIONS OF THE SINUSES IN THE ADULT FROM A CLINICAL STANDPOINT

It is unnecessary for us to repeat what has already been described in the section upon the interpretation of the skiagram in the skull and in the living person. We wish, however, to emphasise certain anatomical points which bear more directly upon the clinical value of the X-ray picture.

(a) *The Frontal Sinus.*—Although the older method of investigating the frontal sinus by electric transillumination undoubtedly possesses some

value as a means of delineating the vertical portion of the cavity in the frontal bone, it frequently fails us when it is most desirable that we should obtain definite information as to whether the sinus is present or not. Further, it is quite useless as a means of ascertaining the existence of a horizontal or orbital extension of the cavity or for the purpose of defining its relations with the ethmoidal cells. If a frontal sinus exists it is possible to demonstrate its presence by skiagraphy, provided that the picture is a good one and that the rays have passed through the head at the correct angle. Should the skiagram not be satisfactory a second or even a third one should be taken in order to settle this point.

If the rays have been incorrectly directed through the sagittal diameter of the head from a point too far above the external occipital protuberance a small frontal sinus may, in consequence, be invisible in the lower part of the frontal bone. If, on the other hand, the rays have been transmitted through the skull from a point some distance below that landmark, the ethmoidal cells may be projected on to the frontal sinus area, and thus deceive us as to the true condition. Coakley has pointed out that a small frontal sinus lying parallel with the supra-orbital margin may escape detection upon the skiagram (*Ann. of Otol., etc.*, 1905). Apart from these faulty or exceptional conditions, if a frontal sinus exists the antero-posterior skiagram will reveal it, and if there should still be any doubt in the observer's mind a profile view of the head will prove of further assistance. From time to time the surgeon has operated upon the frontal sinus area and found that the cavity was absent; with a preliminary use of the X-rays this mistake should no longer be made.

In the head figured on Plate XXV. there are no frontal sinuses, while on Plate XXXIII. the right frontal sinus is absent, hence the appearance presented by the skiagram in the absence of a frontal sinus can be compared in these two Plates with what is seen in many others in the series in which frontal sinuses are depicted. On Plate XXXIII. the contrast can be the more readily noted because a small left sinus is present.

In addition to the value of the knowledge which is derived from ascertaining that a sinus exists, further useful information is obtained.

Thus we become acquainted with the size of the cavity, the presence of recesses or pockets, the existence of a supra-orbital extension, the position of the septum between the two sinuses, and the relation of the anterior ethmoidal cells to the floor of the frontal sinus. We have already dealt with the appearances which the skiagram reveals when recesses are present and when a well-marked orbital extension exists (p. 10, also Plates XXIII. and XXVI.). Variations in the position of the inter-sinus septum can be readily demonstrated. We have not been able to show in our series of plates any marked deviation of the septum from the mesial plane. It is well known, however, that occasionally it assumes a very oblique position, so that one sinus, the right for example, may occupy a limited area above the supra-orbital margin, and the left may in consequence extend across the mesial plane almost to the supra-orbital margin of the other side. Under such circumstances the left sinus might be accidentally opened by the removal of the anterior table of bone in an operation planned for dealing with a diseased right sinus. The preliminary use of the X-rays would prevent this mistake. On Plate XXXIV. we have an example of a deviated septum, the right sinus being considerably smaller than the left.

The relation of the floor of the frontal sinus to the underlying anterior ethmoidal cells is a factor of very considerable importance in determining the possibility of establishing drainage between the sinus and the nasal cavity. The importance of this point and its detection by means of the skiagram has been emphasised by Mosher (*The Laryngoscope*, St. Louis, 1906). For this purpose the profile view is necessary. We know from anatomical study that the nasal portion of the floor of the frontal sinus in the region of the ostium frontale may have a very small antero-posterior diameter; that is to say, the posterior wall of the cavity may approximate so closely to the anterior wall in this situation that there is not room for more than the ostium. On the other hand, its antero-posterior depth may be very considerable; consequently we may find that a part of the anterior ethmoidal cell area lies subjacent to the floor of the sinus, the removal of which will permit of the establishment of a large opening between the sinus and the nasal cavity. The lateral

view of the skull figured on Plate XIII. illustrates the existence of a wide communication between these two cavities.

It is obvious, therefore, that if the surgeon can make himself acquainted before operation with all the anatomical facts which we have just enumerated he is able to consider the question of operative procedure from a broader standpoint than he could otherwise do. Thus the difficulty in deciding anatomically as to the expediency of carrying out an intra-nasal operation upon the frontal sinus will be lessened if it is known that the cavity is small and contains no recesses or partial septa, if there is no orbital extension, and if there is naturally a considerable area of the sinus floor in direct contiguity with the anterior ethmoidal cells. Such anatomical factors at any rate would conduce to a more favourable result than would be obtainable if the sinus were large and irregularly shaped, owing to the formation of pockets and septa. Moreover, good access to it by reason of its relation to the ethmoidal cells would not only diminish the risk of the intra-nasal operation but it would also tend to ensure more favourable drainage during the after-treatment.

Again, if the frontal sinus were large, and if a well-marked orbital extension existed, a Killian operation might be decided upon. Consequently the long skin incision and the mapping out of the supra-orbital "bridge" with preservation of its periosteum would be carried out at once, while the anterior wall of the sinus could be completely removed without the necessity of first dividing its lining mucous membrane and finding out the extent of the cavity by probing. If the profile skiagram demonstrated a very deep sinus the surgeon would realise that considerable disfigurement would probably follow the Killian procedure, and he would thus be able to warn his patient beforehand of the probable effect that such an operation would have upon his appearance. It may also be expedient in the event of the skiagram demonstrating the possibility of removal of the anterior ethmoidal cells through the floor of the frontal sinus to carry out a modified Killian operation without removing the frontal process of the superior maxilla. We have done this in more than one case where the skiagram has demonstrated that the relationship of the floor of the sinus to the anterior ethmoidal cells was a large one. It was

sufficient to remove these cells from above by enlarging the ostium frontale. If this modification is intended it is unnecessary to carry the preliminary skin incision down the side of the nose and beneath the inner canthus.

Further, in dealing with ethmoidal suppuration, if we are able to recognise the extension of the ethmoidal cells into the roof of the orbit it is useless to attempt their radical treatment by any intra-nasal procedure.

While the X-rays are undoubtedly of most therapeutic assistance in connection with the frontal sinus and fronto-ethmoidal region, they may also prove serviceable prior to operations upon the *maxillary sinus*. We have already referred to their value in childhood, but even in the adult they may furnish useful information. Thus on Plate XXV. we are able to determine the position of the nasal walls of the two maxillary sinuses. On the right side the outer nasal wall bulges considerably into the cavity of the antrum. For this reason the removal of the inferior meatal wall by the intra-nasal route would present greater difficulties than upon the right side, being less easily accessible. It is also more closely approximated to the orbital and facial walls of the cavity. Again, the relation of the floor of the sinus to the floor of the nasal cavity, that is to say the presence or absence of an alveolar recess, has a bearing both upon intra-nasal and alveolar operations upon the cavity. This can be investigated by a preliminary use of the X-rays. A knowledge of the existence of a palatal recess, as shown on Plate XXXV., would also prove of service to the surgeon before commencing operation.

In connection with the *sphenoidal sinus* preliminary information may be obtained by means of a profile skiagram as regards the antero-posterior depth of the cavity; that is, the distance between the anterior wall of the sinus and the cranial floor can be ascertained. Some idea may also be gained of the thickness of the anterior wall of the sinus, a point of some importance in connection with the choice of instruments and the possibility or otherwise of making a large opening into the cavity.

In relation to this part of our subject it will not be out of place to briefly refer to the value of skiagraphy in estimating the exact position

of probes and cannulae in dealing with intra-nasal operations upon the ethmoidal and frontal sinuses, more particularly in connection with the latter sinus. In the treatment of the frontal sinus by intra-nasal lavage it is often difficult to say whether the end of the cannula has entered that cavity or is merely lying in an anterior ethmoidal cell immediately below the floor of the sinus or in an ethmoidal cell projecting into the cavity of the frontal sinus (frontal bulla). Again, in connection with the establishment of intra-nasal drainage of the frontal cavity the introduction of probes or pilots preliminary to drilling and the insertion of drainage tubes should be carried out under the guidance of the X-rays. For these purposes the fluorescent screen is used, and the exact position of the instruments is noted.

THE SKIAGRAM IN DISEASE

(a) THE DIAGNOSTIC VALUE OF SKIAGRAPHY IN INFLAMMATION AND SUPPURATION IN THE SINUSES

In the light of what we have already said regarding the skiagram as a means of studying the anatomy of the sinuses in the living its usefulness would be sufficiently established. But it is not in that respect alone that it has found a place in nasal surgery. Its value as a diagnostic agent in disease must now be accepted, and the difficulties previously experienced in arriving at a correct diagnosis in many cases of frontal sinus and ethmoidal disease have to a very large extent been overcome. In connection with maxillary sinus suppuration and other diseases of the antrum much valuable information can be acquired, but here it is not so necessary for us to make use of it, because a diagnosis can usually be made by the ordinary clinical methods which are at our disposal. Our experience with skiagraphy in connection with the sphenoidal sinus is comparatively small, but we believe that its more extended use will demonstrate its value in the diagnosis of suppuration in that cavity.

In connection with the diagnosis of pathological conditions in a sinus we have to note and endeavour to appreciate the changes which take place in what we have learnt to regard as the normal shadow. The

change may be described as a cloudiness or fogging of the area occupied by the sinus. In the case of the frontal sinus particular attention must also be paid to the alteration in the character of its outline. The clear, well-defined margin which we associate with the normal becomes blurred or hazy, and in some cases the blurring of the outline is of more diagnostic value than the increased density of the shadow. Certain variations in the normal are natural owing to varying anatomical conditions such as the depth of the cavity and the thickness of its walls. Similarly, when pathological conditions are present the shadow significant of disease will vary with the contents of the sinus and with the intensity of the change in its lining membrane or bony walls.

In order to estimate at their true value the alterations from the normal shadow experimental work was carried out by Scheier, and later by Chisholm and Albrecht. It was found that glass tubes filled with water or normal saline interrupted the passage of the X-rays and produced a denser shadow than that which was cast by a tube which only contained air. A still denser shadow was obtained when the tube was filled with pus. Having demonstrated that alterations resulted from a change in the contents of a cavity, Chisholm experimented with intestinal mucous membrane and found that when moistened it produced a much deeper shadow than when exposed to the rays in a dried condition, and that its density increased in proportion to the thickness of the moist mucosa. Further experiments were then made upon skulls. The frontal sinuses were skia-graphed, and then one of the cavities was filled with gelatine and a second exposure was made. The sinus thus treated now gave a very dense shadow, in striking contrast to that upon the opposite side. He found, too, that an empty frontal sinus with a normal mucous membrane presented a clear, sharp outline, but when filled with fluid, even when its lining membrane was normal, it gave a cloudy appearance with its outline less well defined. From his experiments with the moist intestinal mucosa Chisholm considered that we might justly infer that a frontal sinus lined with thickened so-called polypoid mucous membrane will present the same blurred appearance as when filled with fluid.

Albrecht's experiments upon the maxillary sinus furnish additional

evidence of the probable effect of inflammation upon the appearance of the shadow (*Arch. f. Laryngol.*, Berlin, 1907). A skiagram of the skull was made, and the appearance of the antrum was noted. A quantity of pus was then injected into the cavity, and a second exposure was carried out. An increase in the density of the shadow of the sinus thus treated was observed. After a still larger quantity of pus had been injected an even darker shadow was produced. Albrecht found clinically, however, that when the maxillary sinus with a thickened lining membrane and with purulent contents was washed out and immediately skiagraphed there was practically no difference between the shadows before and after syringing. It is evident, therefore, from what has been said that inflammatory changes in a sinus will produce a cloudiness or an increase in the density of its normal shadow, but no definite statement can be made as to whether the change is due to the presence of secretion in the cavity or to an alteration in the thickness of its lining membrane.

Unless more extended experience can throw further light upon this subject it will not be possible for us to draw any definite conclusions as to whether the pathological changes in the lining mucous membrane have proceeded further in one patient than in another. Again, where more than one cavity is affected in the same patient, as for instance the frontal and maxillary sinuses on the same side, we are not in a position to say from a study of the skiagraphic shadows that one sinus has been affected for a longer period of time than the other, and that one has probably infected the other. Careful skiagraphy of diseased sinuses with subsequent microscopical examination of the lining mucous membrane might prove a useful subject of research.

The diagnostic value of the skiagram in sinus suppuration may be illustrated by the study of a typical case of disease such as is figured on Plate XXVI., in which operation was performed and the diagnosis confirmed. The patient was a young man who had complained of discharge from the left side of the nose for at least three years. On more than one occasion he had had nasal polypi removed. Suppuration in the left maxillary sinus was diagnosed by the ordinary clinical methods. The cavity was opened through the outer wall of the inferior meatus and lavage commenced. In

spite of the improvement which followed the operation pus continued to appear in the middle meatus, and he was conscious of discomfort in the left frontal region and occasional headache. Some purulent discharge continued to come from the antrum. The skiagram on Plate XXVI. was then taken, and by its aid the full extent of the disease can be recognised. On the right side of the picture we can clearly distinguish the normal shadow presented by the frontal sinus, ethmoidal cells, and maxillary sinus, and if they are compared with the corresponding areas upon the left side a marked contrast in the density of the shadows is at once apparent.

If we examine the frontal area in the first instance we can define the inter-sinus septum occupying the mesial plane. The right sinus is large; its upper two-thirds presents a shadow of moderate density which is unequally sub-divided by a dark vertical line denoting the presence of a partial septum within the cavity. The lower third of the sinus, lying parallel with the supra-orbital margin, is a distinctly clearer area demarcated above by a dark, somewhat irregular, line. This clear area, as already pointed out, indicates the existence of the supra-orbital extension of the sinus. The contour line of the sinus is clearly defined. The left frontal sinus is smaller than the right, and to the unpractised eye it may at first sight be difficult to define. Careful observation, however, will reveal the fact that it does not extend so far upwards upon the forehead as the right sinus, while its extension outwards above the supra-orbital margin is practically the same as that of the opposite side. The outline of the cavity has lost its definition, and presents a blurred, somewhat indistinct appearance. The shadow of the sinus is dark and contrasts markedly with that of the opposite side. There is no evidence of any incomplete septa or recesses in the sinus. The shadow immediately above the supra-orbital margin is less dense than that of the general area of the sinus, and this would indicate an orbital extension of the cavity. The appearances thus presented confirmed our suspicions that the frontal sinus was diseased.

In the left ethmoidal region, also, a dark shadow is observed, and when compared with the corresponding area on the opposite side the contrast is obvious. A diagnosis of fronto-ethmoidal sinus suppuration was made,

and a Killian operation was performed. The frontal sinus contained a small quantity of pus, and the lining membrane had a thickened œdematous appearance. The sinus extended along the roof of the orbit and formed a fairly well marked recess in that situation. There were no incomplete septa or pockets in the cavity. A well-developed ethmoidal cell or "frontal bulla" projected into the floor of the sinus. With the exception of this the anatomical appearances and the pathological changes suggested by a study of the skiagram were confirmed by what was found at the operation. In the anterior ethmoidal cells pus and thickened mucous membrane were also met with.

The left maxillary sinus presents a very dense shadow in which all detail is lost, and it is somewhat difficult to follow the outline of the cavity. It offers a distinct contrast to the sinus upon the other side. The actual change in the mucous membrane of the left antrum was not observed, however, because no further operation upon it was required. The cavity ceased to discharge after the other sinuses had been treated, though it was necessary to continue washing it out for a considerable time through the opening which had previously been made in the outer wall of the inferior meatus.

We have reproduced on Plate XXVII. the negative from a case of left-sided frontal, ethmoidal and maxillary suppuration.

While the case just described is an illustrative example of many similar cases which we have from time to time skiagraphed and proved the accuracy of the skiagram by subsequent operation, the actual appearances suggestive of disease presented in different pictures have not always been the same as in this case. We are anxious to emphasise this point, namely, that a diseased sinus, whether frontal, ethmoidal, or maxillary, does not always show the same degree of fogging as we see on Plate XXVI. We have already indicated how the shadow of the sinus in health will vary; similarly the degree of fogging will vary in diseased conditions. If we compare Plate XXIX. with Plate XXVI. we find that the diseased ethmoidal cells in the former case present a deeper shadow than the diseased left ethmoidal cells on Plate XXVI. In the same way the diseased right antrum on Plate XXXII. does not present nearly so dense an appearance as the affected antrum on Plate XXVIII. If we examine Plate XXVIII., in which there is

illustrated chronic suppuration in the right maxillary sinus, we observe that the right ethmoidal cells present a darker shadow than those upon the left side; nevertheless, in spite of this degree of shadowing there was no clinical evidence to warrant a diagnosis of right ethmoidal cell suppuration. The shadows of the frontal sinuses in this case are dark, and even their outlines are not so well defined as we might naturally expect to see them in the healthy state; they are, however, identical upon the two sides. The statement has been made that the shadow of a shallow frontal sinus may closely simulate a diseased condition, so that due care must be taken in estimating the exact value to be placed upon the interpretation of the skiagram in some cases. A profile view will be of assistance when we are in doubt as to this point. The depth of the sinus will thus be ascertained.

As Killian has pointed out, all the sinuses in the same skiagram may appear slightly fogged without any special significance being attached to such an appearance. If a marked degree of shadowing be present all over the picture we must assume either that all the sinuses are affected or that the whole plate is technically faulty. In such a case a second skiagram would be advisable before any conclusion is drawn. If, on the other hand, there is a considerable degree of shadowing all over the plate and certain sinus areas are particularly dense it would be fair to assume that the latter were diseased.

When bilateral disease is present a difficulty in the interpretation of the skiagram arises because we no longer have a corresponding healthy cavity for purposes of comparison. On Plate XXIX. we have illustrated a case of so-called "pansinusitis" in which all the sinuses were diseased, and where proof of this was obtained by operation. In the case of the frontal sinuses some doubt might naturally be expressed as to their existence, but a study of the negative in this case would admit of no doubt upon this point, and operation demonstrated their purulent contents and thickened mucous membrane. We would take this opportunity of emphasising the value of a careful study of the negative in all cases, especially in those in which any difference of opinion existed as to the actual condition present. On Plate XXIX. there is a more or less uniform shadowing of all the sinuses, and a comparison with the appearance in a normal head leaves no room for doubt as to their diseased condition.

In studying this subject the question must naturally arise, Can the skiagram always be regarded as a perfectly reliable aid in diagnosis? To this we must reply in the negative, not only from our own experience but from the evidence of others. It is true that in our experience we would appear to have been very fortunate, as we can only cite two examples in which we have been deceived by the appearance of the skiagram. It is necessary, however, to qualify this statement by saying that all the cases which have been skiagraphed in which the appearance of the shadow led us to believe that disease was present have not come to operation, consequently we have not been able to prove the correctness or otherwise of all our observations. In one of the two cases referred to the clinical signs pointed to frontal sinus suppuration; the shadow on the skiagram suggested that possibly disease might be present; at the same time neither the density of the shadow nor the character of the contour line of the sinus was of such a nature as to lead us to feel certain that suppuration existed. At the operation, however, the frontal sinus was found markedly affected. On the other hand we have notes of two cases in each of which one of the frontal sinuses was opened on account of the very suggestive clinical manifestations of sinus suppuration. In neither case was any disease found. If the surgeon had placed greater confidence in the appearance presented by the skiagram in each of the cases he would not have operated. In both cases the frontal sinus shadow and outline were those of a normal cavity. On Plate XXX., a case of ozæna, the appearance presented by the left maxillary sinus in contrast with that on the right side seemed to justify the diagnosis of antral suppuration. The cavity was punctured and washed out, but the solution returned quite clear and free from any suspicion of discharge. Deceptive appearances in the skiagraphic shadow in the case of the maxillary sinus are not of such great importance, because we can more readily arrive at a correct conclusion by other clinical methods. In the case of young children, however, where puncture and washing out of the cavity is naturally attended with difficulties, and may indeed be impossible under local anæsthesia, skiagraphy is of value, and hence a correct knowledge of antral shadows is important.

Albrecht from his experience is unable to regard the shadow of the

skiagram as an infallible means of diagnosis because he has found the X-rays disappointing as a result of observations upon the cadaver and in the living subject. The importance of this point justifies us in quoting his experience. The head of a cadaver was skiagraphed; both frontal sinuses were equally clear and their margins were sharply defined. The cavities were then opened and inspected. On one side a normal thin, smooth mucosa was found, and the sinus contained no secretion; on the other side the mucous membrane was cedematous and irregularly thickened, and in the lower part of the cavity it was covered with muco-purulent secretion. There was no free secretion in the cavity. Microscopically small cell infiltration, thickened connective tissue, and in some areas a tendency to polypus formation were noted. In another cadaver where unilateral frontal sinus disease existed the skiagram failed to show the appearances suggestive of disease. In both these cases, therefore, the pathological changes in the frontal sinuses were associated with skiagraphic shadows recognised by experience as normal. In two patients, also, who were operated upon by him the appearances presented by the skiagram did not correspond with what was found in the sinus. Here, however, the appearance of the shadow upon the suspected side seemed to corroborate the clinical diagnosis of frontal sinus disease by reason of its density, while the sinus on the opposite side presented a sharply defined normal appearance. When the suspected sinus was opened it was found to be healthy, its lining mucosa being smooth and glistening. The dense shadow of the skiagram could not be explained on the ground of the cavity being shallower than its neighbour, nor did there appear to be any special thickening of its osseous wall. It is evident, therefore, from these cases that the skiagram may present an apparently normal shadow when disease exists in the frontal sinus; and again, the shadow may simulate a diseased condition when no pathological changes have taken place.

It will not be out of place to briefly refer at this stage to the possibility of a diseased ethmoidal cell simulating an affection of the frontal sinus. It is well known that an anterior ethmoidal cell may extend for some distance into the cavity of the frontal sinus constituting what has been termed the "frontal bulla." Suppuration may be present in this cell in association with

disease in the ethmoidal labyrinth, and the frontal sinus may remain free from infection. It will be readily understood how such a cell lying in the vertical part of the frontal bone may produce a shadow in the skiagram which might simulate disease of the frontal sinus itself. Albrecht indeed describes a condition of this kind which he found in a cadaver. The skiagram showed on both sides in the frontal sinus areas an indistinct, hazy shadow, and the frontal sinuses could not be differentiated. The ethmoidal labyrinth appeared to extend upwards in an unusual degree, and its upper boundary could be recognised within the frontal bone. A dissection was made, and on each side a large frontal bulla was recognised. On the left side the cell contained sero-mucous secretion, and its lining membrane was swollen and œdematous; on the right side the cell was filled with thick, stringy pus. The frontal sinuses were of moderate size, and showed no evidence of disease.

It is probably in connection with the ethmoidal cells that we obtain the greatest satisfaction in diagnosis by the employment of the skiagram. Under normal conditions the ethmoidal region is clearly defined; owing to the extent of its antero-posterior diameter and on account of the thinness of the osseous laminae by which it is built up the normal shadow is as a rule a faint one, consequently any departure from the normal readily shows itself in the skiagram. A clear impression will usually signify a condition of health, and a dense shadow will usually imply a pathological change. The latter need not necessarily mean that pus is present in the cells, but it will indicate an inflammatory change in the lining mucous membrane of some at any rate of the cells. The difficulty in making up our minds as to the presence of ethmoidal cell disease—especially in the posterior group—in some of those cases associated with serious ocular changes, and the necessity of making a diagnosis in these cases, increases the importance of carefully studying any new method which may facilitate diagnosis. We have had practical experience of the value of the skiagram in a case of this kind in which persistent headache, a unilateral retro-bulbar neuritis, and subsequently the development of paralysis of the fourth nerve led to a careful examination of the accessory sinuses. In spite of repeated nasal examination no trace of pus or œdema of the ethmoidal mucous membrane could be

detected, and the patient himself denied the existence of nasal or post-nasal discharge. On two different occasions a skiagram revealed a distinct shadow in the ethmoidal region on one side, the other sinuses presenting a normal appearance. The middle turbinated bone was therefore removed and the posterior ethmoidal cells and the sphenoidal sinus investigated. No pus was detected, but an œdematous condition of the mucous membrane in the posterior ethmoidal cells and inflammatory changes in the osseous laminae were observed by microscopical examination of the tissue. A somewhat similar case is recorded by Albrecht in which headache and early optic atrophy on one side, associated with diminution in the visual field, raised the suspicion of sinus disease. No trace of pus could be found in the nasal cavities, but the skiagram revealed a dense shadow in the corresponding ethmoidal region. After opening the ethmoidal cells no pus could be detected, but their lining mucous membrane was swollen and œdematous. After the operation the headache disappeared, and there was a marked improvement in vision. In both these cases the skiagram proved of valuable assistance.

We have not been able to satisfy ourselves of the possibility of differentiating between disease of the anterior and posterior groups of cells by this method. Albrecht, however, speaks of the great importance of skiagraphy in determining the presence of disease in the anterior group of cells, but he is unable to claim the same for it in the diagnosis of the posterior group. Nor does the profile view appear to map out the area of disease, because the projection of the clear healthy cells upon the other side of the nasal cavity apparently interferes with the recognition of a unilateral affection. Possibly we may in the future obtain more reliable information upon this point by employing Pfeiffer's method of taking the skiagram through the vertical diameter of the head, whereby the ethmoidal cells on each side may be inspected throughout their antero-posterior diameter.

In connection with the diagnosis of sphenoidal sinus suppuration, both from our own experience and from that of other workers in this field, it is obvious that there is still more work to be done. Neither the antero-posterior nor the profile skiagram gives reliable data. In the former the shadow of the ethmoidal cells, whether healthy or diseased, interferes with the interpretation

of the sphenoidal area, while in the profile view the projection of one sphenoidal cavity upon the other is necessarily a disadvantage. If the ethmoidal cells are affected in conjunction with the sphenoidal sinus, as they so frequently are, the shadow which the former produce will lead the surgeon to explore them. At the same time the sphenoidal sinus is probably brought under his observation, and he is thus enabled to investigate it. Pfeiffer's method of depicting the sphenoidal cavities certainly appears to offer facilities for the diagnosis of disease, and a more extended experience of the skiagram taken through the vertex will probably give us more assistance. In his paper on this subject he illustrates a case in which a solution of bismuth was injected into one of the cavities: the difference between the density of the two shadows is clearly depicted in the skiagram. A control picture of the same patient prior to the injection of the bismuth shows both cavities equally clear. In another case in which the mucous membrane of the left sphenoidal and ethmoidal cells was thickened and œdematous the shadow of these cavities offers an obvious contrast to that of the healthy sinuses upon the opposite side.

(b) THE DIAGNOSTIC VALUE OF THE SKIAGRAM IN OTHER CONDITIONS OF THE SINUSES

Up to this point we have dealt solely with the use of skiagraphy in the inflammatory affections of the accessory sinuses. Our object now is to illustrate its employment in some of the less common conditions which are from time to time met with in this region. Some of these we have been able to illustrate from our own experience.

Mucocele of the Frontal Sinus.—On Plate XXXI. an example of this condition is shown. By the term mucocele we understand a distension of the cavity and the accumulation within it of a mucoid or sero-mucoid secretion, resulting from a partial or complete obstruction of its normal outlet; one or more of the bony walls of the cavity become thinned and absorbed. The case illustrated on Plate XXXI. was a condition of this kind affecting the right frontal sinus. The patient was a woman with a painless, somewhat elastic, swelling in the upper and inner angle of the right orbit, causing a downward, forward, and outward displacement of the eyeball. She gave no history of any nasal discomfort. A study of the skiagram will show that the

left frontal sinus does not exist, so that we are unable to compare the shadow of the mucocoele with that of a normal sinus upon the opposite side. If compared, however, with the normal frontal sinuses in other heads, we are struck with the fact that the shadow is distinctly less dense than that presented by a healthy cavity; the outline is well defined. At the operation the frontal sinus was found to contain a large quantity of clear serous fluid. Its lining membrane was thin and smooth. The floor of the sinus had been completely absorbed; the posterior or cerebral wall showed a large defect, exposing the dura mater over a very considerable area. Notwithstanding the fact that the cavity was filled with fluid, and for that reason alone would give a darker shadow than a normal empty sinus, the skiagram, as we have said, shows it to be lighter than normal. The explanation of this is to be found in the absence of the posterior or cerebral wall of the sinus. In other words the X-rays in this case had traversed only one osseous wall, namely the anterior. If we compare the left frontal sinus area on Plate XXXVIII., where a Killian operation has been performed, and where, consequently, the anterior wall of the sinus has been removed, we see a very similar, and indeed even a lighter shadow than that presented by the mucocoele. This is due to the removal of the anterior osseous wall of the sinus, which, on account of its thickness, is even a greater cause of obstruction to the rays than the posterior wall. We have been able to demonstrate this appearance of the shadow in other cases after the Killian operation. A similar appearance may be observed upon Plate IX., where the anterior wall of the left frontal sinus has been removed.

While the skiagram of a frontal mucocoele presents the appearance which is shown on Plate XXXI. it does not do so in every case; the changes in the bony walls of the sinus are not always the same, and the character of the contents of the cavity varies. The latter may be of an opalescent character and of thicker consistence than in the case just recorded, and this will naturally interfere to a greater extent with the transmission of the rays and produce a denser shadow. Again, if the mucocoele becomes infected, as it may be, with pyogenic organisms, and the contents become purulent, a denser shadow will be produced, such as is illustrated upon Plate XXXII. Here we have a mucocoele of the right frontal sinus in a woman. She had complained of a painless swelling in the upper, inner part of the right orbit for at least one

year. The eyeball was displaced downwards and outwards. There had never been any discharge from the nose. Shortly before her admission she complained of pain above the right eye, and for that reason she had sought advice. At the operation it was found that the entire floor of the sinus had been absorbed, and there was no trace of the posterior or cerebral bony wall of the cavity. The lining membrane of the sinus was thin and smooth, presenting an appearance similar to that which we have seen in mucocoeles of these cavities. The cavity, however, was full of thick, creamy pus. The history and the appearances, therefore, led us to the conclusion that an old-standing mucocoele had recently become infected with pyogenic organisms. The density of the skiagraphic shadow was produced by the character of the contents in spite of the fact that the whole of the posterior wall of the sinus had disappeared. It is interesting to observe that even though the lining membrane of the sinus appeared unaltered the outline of the cavity was blurred, and had lost its well-defined character. In the previous case, however (Plate XXXI.), where the lining membrane was thin and the contained fluid was clear, the outline of the sinus remained sharply defined. This last observation does not tally with that made by Chisholm in his experimental work upon the frontal sinus (p. 27).

Dental Cysts Invading the Maxillary Sinus.—We have had the opportunity of skiagraphing a number of cases in which dental cysts of considerable size had gradually enlarged at the expense of the antral cavity, causing thinning and bulging of the canine wall, and sometimes also producing a similar change in the lower part of the nasal wall of the sinus. On Plate XXXIII. we have figured one of these cases, and the skiagram demonstrates the cavity of the cyst occupying the greater part of the right maxillary sinus. The cyst presents a darkly-shadowed area in the lower two-thirds of the antrum, and is separated from the upper part of that cavity, which is clearer, by a well-defined dark line. In this case there is no evidence to show that the mesial wall of the cyst had bulged into the nasal cavity, a point which we had already satisfied ourselves upon by anterior rhinoscopy, and which was corroborated at the operation. The cyst contained a tenacious, milky fluid, and its upper wall presented the vaulted appearance which is indicated by the dark line in the skiagram. In order to satisfy ourselves of the correctness of the skiagram

the superior wall of the cyst was removed, and the upper part of the maxillary sinus was opened into. This was found to be healthy and lined by normal mucous membrane. The operation was concluded by removing the whole of the cyst wall and draining the cavity into the nose by establishing an opening through the outer wall of the inferior meatus. In another case of a very large dental cyst we were unable to differentiate between the cavity of the cyst and the cavity of the sinus, and we concluded that the whole of the maxillary sinus was probably replaced by the cyst. This view was confirmed at the operation. No profile skiagram was taken in any of our cases, so that we had no opportunity of determining the extent to which the cyst had developed in the posterior part of the sinus.

Naso-Antral or Choanal Polypi.—From time to time we meet with what is now a well-recognised type of case characterised by the presence on one side of the nose of a single polypus occupying the posterior part of the nasal cavity and passing through the choana into the naso-pharynx. The polypus may even appear below the soft palate, and in some cases it sends a prolongation forwards in the nasal cavity which may reach the anterior nares. These polypi occur most frequently in young people, and a large cyst is usually present in their interior. Their origin from the mucous membrane of the maxillary sinus was first pointed out by Killian. The cystic polypus passes out of the antrum through an accessory ostium in the membranous wall of the middle meatus. It is sometimes possible to distinguish by anterior rhinoscopy the stalk of the polypus as it lies beneath the posterior part of the middle turbinated body. It consists, therefore, of a large cystic portion within the sinus and an expanded portion in the nose and naso-pharynx, the two being connected by a narrow, stalk-like neck.

A number of these cases have passed through our hands, and we have had an opportunity of taking a skiagram in eight instances. Our purpose here is not to discuss their pathology, but merely to draw attention to the alteration which they produce in the normal shadow of the maxillary sinus. In all our cases the skiagram showed a denser shadow than that of a normal maxillary sinus. It is interesting in this connection to note the appearance which is presented by the antral cavity in these cases in ordinary electric transillumination. In seven of the eight cases in the series the transillum-

ination upon the affected side was brighter than that upon the opposite side. With one exception the other sinus was a normal cavity; in the exception we had to deal with suppuration in the maxillary sinus on the side opposite to the choanal polypus. In the eighth case the two antra illuminated equally. An explanation of this phenomenon of transillumination has been suggested by Brown Kelly (*The Lancet*, London, 1909). In the normal antrum the concave bony walls and the smooth, shining lining membrane cause a condensation of light, and thus favour transillumination. As the polypus within the maxillary sinus is of a cystic nature transillumination is still further favoured by two factors—first, the decrease of diffuse reflection by the obliteration of the irregularities of those portions of the antral wall with which the sac of the cyst is in contact, and secondly, further condensation of the light caused by refraction due to the presence of fluid in the sac.

If we bear in mind what has already been said regarding the effect of the presence of fluid upon the skiagraphic shadow of a sinus we can readily understand why in the skiagram the antrum containing the cystic polypus produces a denser shadow than that of the normal sinus. This occurred in all our cases, although the general lining membrane of the antrum presented a normal, thin appearance, and there was no pus or free fluid within the sinus. Plates XXXIV. and XXXV. represent two examples of naso-antral polypi upon the left side. On Plate XXXV. both maxillary sinuses present shadows suggesting a pathological condition. The left antrum contained a cystic polypus which passed into the nasal cavity and naso-pharynx through a large opening in the membranous wall of the middle meatus. The appearance of the shadow in the right side led us to puncture and wash out the cavity. A muco-purulent secretion was obtained from it. On Plate XXXIV. the left antrum was found to contain the attachment of the choanal polypus, the sac occupying a considerable part of the cavity. The shadow of the antrum is darker than that of the healthy right sinus. In another case, which we have not illustrated, the polypus was a large one, and sent a prolongation forward to the anterior nares. In the skiagram not only was the antral shadow upon the affected side distinctly darker than that of the opposite healthy sinus, but the nasal cavity occupied by the polypus was also darker than the opposite normal nasal cavity. From our experience of these cases

we have come to the conclusion that if any doubt should exist as to the seat of origin of these single polypi a skiagram will prove of considerable diagnostic value.

Malignant Disease of the Accessory Sinuses and Nasal Cavities.—In the diagnosis of malignant disease in this region it is often very difficult, and indeed it may be impossible, to determine the extent of the growth by the ordinary clinical methods at our disposal. It is obvious that if the surgeon can satisfy himself as to whether the tumour is confined to the interior of the nose, or whether, starting in the ethmoidal labyrinth or maxillary sinus, it has not yet invaded neighbouring cavities, his method of operative procedure will be considerably influenced. We have not had many opportunities of skiagraphing cases of this kind, but in six instances we were able to assist the surgeon in determining the extent of the disease by this method of examination when other clinical methods failed to give us the same amount of information. On Plate XXXVI. one of these cases is figured. The patient was a woman, aged fifty-three, who complained of complete obstruction of the right side of the nose of three months' duration; during the same time she had been troubled with the passage of the tears over her right cheek, but the history of a nasal discharge extended over a much longer period. The right nasal cavity was obstructed by a grey sloughy mass. The right choana was free, with the exception of a small area in its roof where a similar grey patch was visible. A slight fulness could be detected in the right canine fossa, and the cheek appeared a little swollen. The right eyeball was not displaced.

The skiagram indicates clearly the unilateral nature of the disease. The position of the nasal septum is defined, and on the left we can differentiate the normal nasal, maxillary, ethmoidal, frontal, and orbital cavities. On the right side the contrast is very striking. A shadow of more or less uniform density occupies the position of all the cavities, blurring their outlines and rendering their definition difficult. We wish to draw particular attention to the inner aspect of the right orbit and the inner third of its supra-orbital margin, because it was found at the operation that the tumour not only involved the right nasal, maxillary, and ethmoidal cavities, but it invaded the os planum of the ethmoid upon its orbital aspect and also the roof of the

orbit in the region of the floor of the frontal sinus. A study of the skiagram will, we think, demonstrate to the observer that this extension of the disease can be recognised. It was further found during the operation that the disease had invaded the body of the sphenoid bone, but no profile skiagram had been previously made. We wish to draw attention to the valuable information which may be gained by studying both an antero-posterior and lateral view in cases of malignant disease in this situation. In another of our cases we were able to show by a profile skiagram that the tumour had involved the sphenoidal sinus (Plate XXXVII.).

Foreign Bodies in the Accessory Sinuses.—A few words may be added in reference to the detection of foreign bodies in the maxillary or frontal sinuses. Occasionally, though not so frequently as formerly, drainage tubes have been lost in the frontal sinus. We say not so frequently as formerly because with our modern methods of dealing with the frontal sinus drainage tubes have been largely dispensed with. The skiagram, however, will serve a useful purpose should any suspicion arise as to the possibility of a foreign body of this kind being present. The same remarks would apply equally to the disappearance of an antral obturator. A case of this kind recently came under our notice where a patient asserted that the obturator which she had been wearing attached to her tooth-plate had been accidentally broken off. The skiagram which was taken showed plainly its position within the cavity of the antrum; it was removed through an opening in the canine fossa.

THE SKIAGRAM IN ESTIMATING THE RESULT OF TREATMENT

It is possible to utilise the skiagram in estimating the progress of the case during treatment. It has long been our practice to employ electric transillumination for this purpose in cases of acute frontal sinus inflammation, and in maxillary sinus suppuration undergoing treatment by lavage, and we have been able to observe the gradual disappearance of the opacity previously noted before the commencement of treatment. We have found it possible by means of the skiagram to make similar observations, and we have seen the shadow significant of disease disappear, and finally have been able to produce a picture in which the appearances presented on the two sides have been the same, that

on the previously affected side being consistent with a normal condition of the cavity.

Skiagraphy, however, offers greater advantages in this respect than transillumination, because it not only furnishes information regarding the progress of cases which are treated by lavage, but it enables us to estimate the condition of a frontal or maxillary sinus which has been treated by radical methods. In other words, we are able to learn whether the cavity has become partially or completely obliterated. Mosher has drawn attention to this point in connection with the frontal sinus. He illustrates two cases in which a radical operation had been performed and the sinuses allowed to obliterate by the formation of granulation tissue. Both cases were cured in the sense that discharge had ceased, but in one it was evident from the skiagram that the frontal sinuses had not been completely obliterated. In each sinus area a shadow was depicted which clearly showed that a year after the operation a small unobliterated area remained. On Plate XXXVIII. we have illustrated the left frontal sinus area after a Killian operation; the supra-orbital margin of bone or "bridge" is seen as a dark line. The clear area above it is uniform, and there is no dark area within it which might suggest that a small portion of the cavity had been left unobliterated. On Plate XXXIX. we have illustrated the appearances presented after a radical operation upon the left maxillary sinus. In this case the antrum was opened through the canine fossa, its lining membrane removed, and a nasal opening established through the outer wall of the inferior meatus. The anterior end of the inferior turbinal was removed. The skiagram shows the inferior meatus of the nose on the left side with the shadow of the inferior turbinal more faintly portrayed than upon the right side. The lower part of the outer nasal wall is seen, and external to it a small clear area limited externally by a well-defined margin. We were able to satisfy ourselves by the introduction of a probe through the naso-antral opening that this area represented the remains of the maxillary sinus. With the exception of this the cavity had been obliterated. If we compare the shadows of the two superior maxillary bones a striking contrast is observed between them. On the right side the normal maxillary sinus can be defined, while a dense shadow occupies the greater part of what was the area of the left sinus.

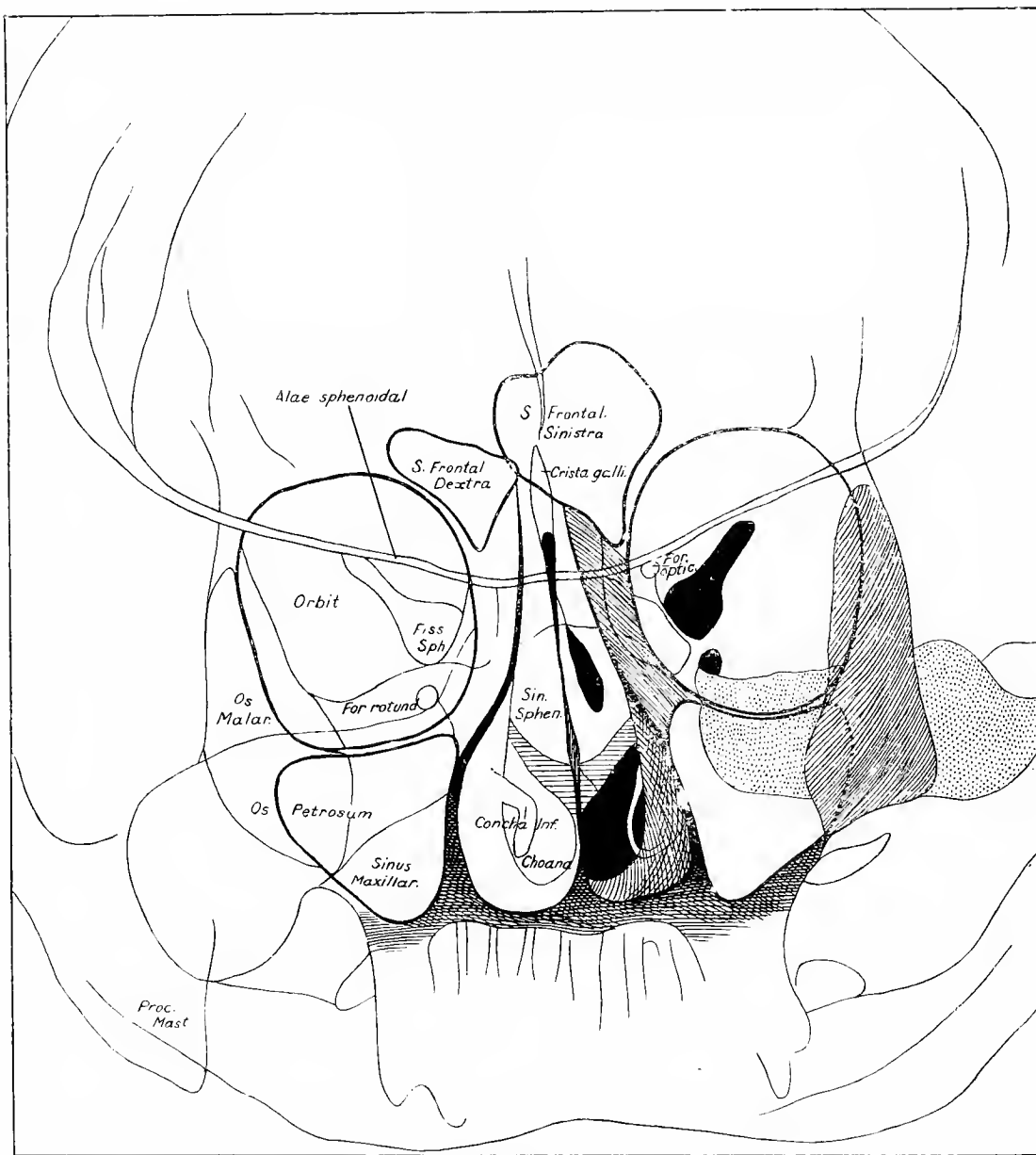
GENERAL CONCLUSIONS REGARDING THE VALUE OF THE
SKIAGRAM IN ACCESSORY SINUS DISEASE

We have come to the following conclusions as the result of a considerable experience in the application of the X-rays to the accessory nasal sinuses. It is well to again emphasise the fact that an inferior apparatus should not be employed, that the X-ray tubes should be correctly tuned, that great care must be taken in posing the patient, and that the exposure should be correct. These are difficulties which may be overcome by practice. Further, we must again draw attention to the necessity of studying a good negative. Lastly, a correct interpretation both of the anatomical detail and of pathological changes is best obtained from the actual study of a large series of skiagrams, both negatives and positives, and not from descriptions in books.

1. Skiagraphy is a valuable aid in the study of the development of the air cavities, and it is the only method by which we can determine in the living, and without any operative interference, the existence of all the air sinuses.
2. By means of the skiagram we can define the size of the frontal sinuses, the position of the inter-sinus septum, the presence of subsidiary partitions in the cavity, and a supra-orbital extension of the sinus. To some extent, also, the relation of the sinus to the anterior ethmoidal cells can also be determined.
3. From the anatomical knowledge derived from skiagraphy we are placed in a better position to decide as to the kind of operation which should be carried out upon the diseased frontal sinus, and, to a lesser extent, also upon the ethmoidal cells.
4. A preliminary study of the skiagram may also be of anatomical assistance prior to operations upon the maxillary and sphenoidal sinuses, but it is not of such importance as in the case of the frontal sinus.
5. Skiagraphy is of undoubted diagnostic value in cases of inflammation and suppuration of the nasal sinuses, but it must be used in conjunction with other methods of diagnosis. It cannot, however, be regarded in every case as perfectly reliable.
6. Its diagnostic value is greatest in connection with disease in the

frontal and ethmoidal sinuses, but we believe that further experience will demonstrate its usefulness in the detection of sphenoidal sinus suppuration.

7. In children in whom it may be inexpedient or impossible to carry out intra-nasal diagnostic procedures, it will prove of undoubted advantage to obtain a skiagram of the sinuses.
8. The skiagram does not allow us to draw any conclusion as to the exact nature of the pathological contents of a sinus or as to the degree of inflammatory change which has taken place in its mucous membrane.
9. By means of the fluorescent screen we are able to ascertain the position of cannulae or other instruments introduced into the sinuses for therapeutic purposes by way of the nasal cavity.
10. The skiagram may be usefully employed for ascertaining the size of dental cysts occupying the maxillary sinus, in determining the origin of choanal polypi, and for assisting us in defining the limitations of malignant growths in the sinuses.
11. It is a valuable diagnostic aid in the detection of foreign bodies in the sinuses.
12. It is of service in determining the effect of treatment upon the inflammatory affections of the accessory sinuses.



Key to face Plate 1.



PLATE I.

Skull of adult ; antero-posterior view showing all the accessory sinuses. The position of the different cavities and of the more prominent landmarks is indicated upon the key.

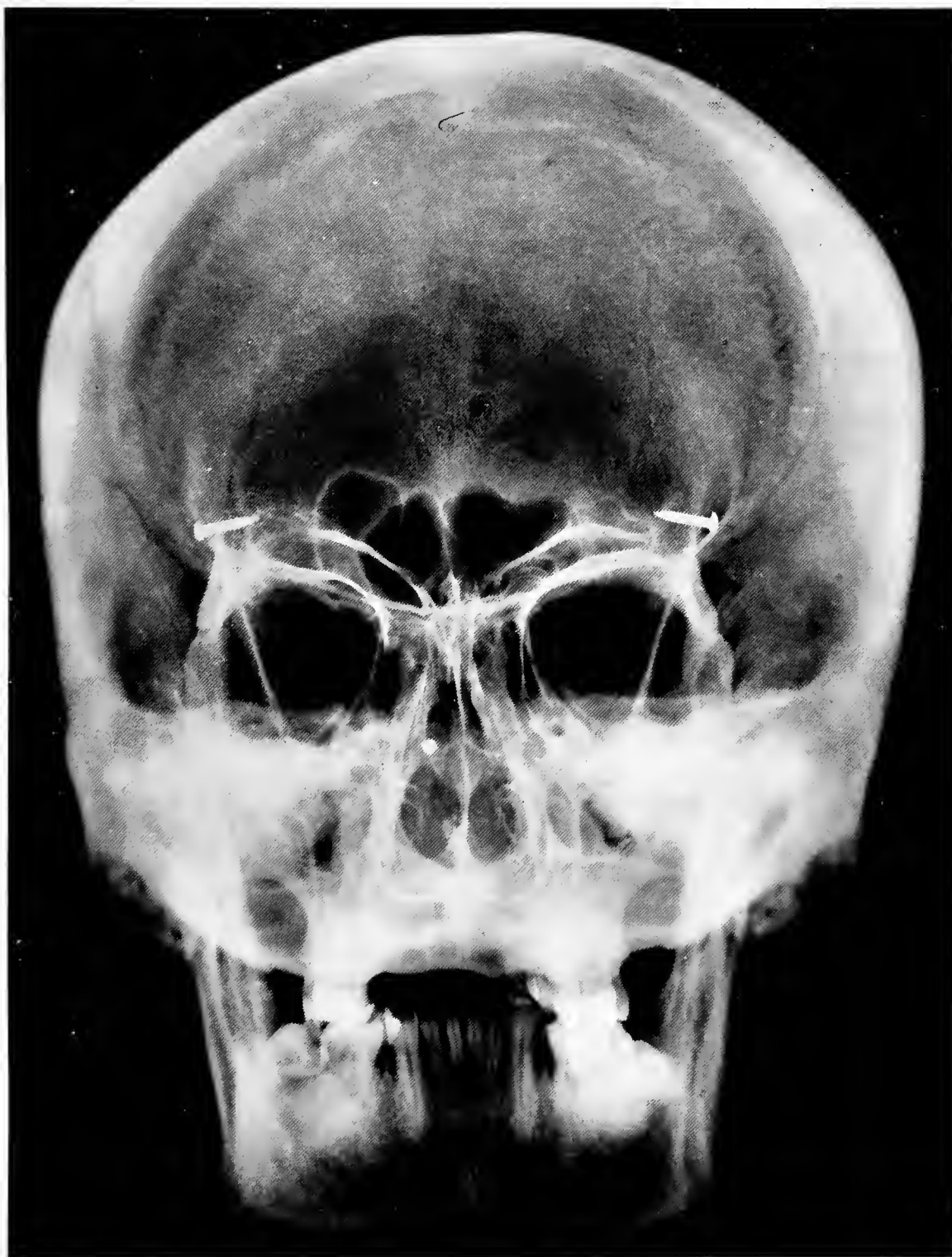


PLATE II.

Skull of adult : this is a reproduction of the negative from which the frontispiece was taken : consequently what is light in the positive is dark in the negative and *vice versa*.

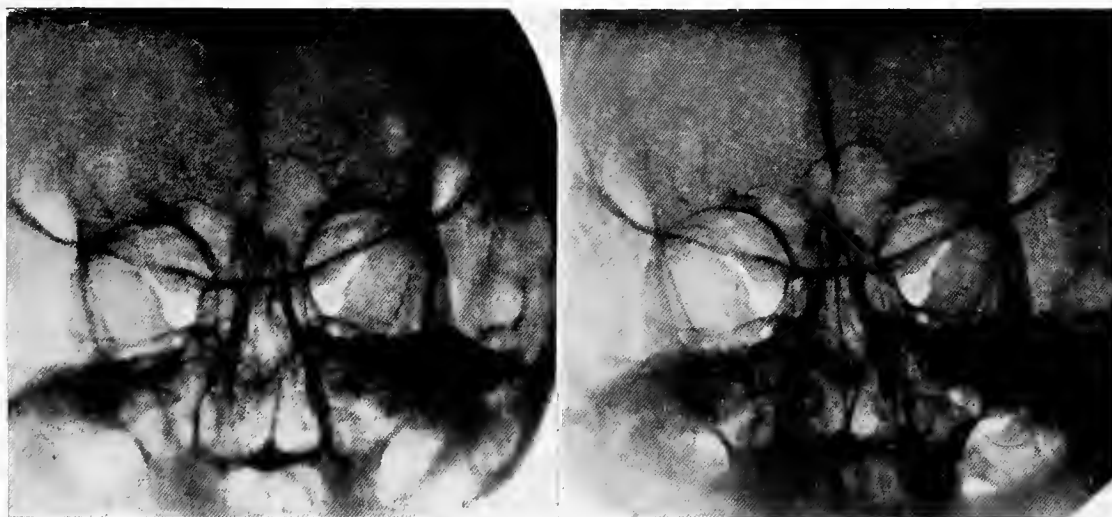


FIG. 1.—A stereoscopic view of the same skull as shown on Plate I. The sinuses are viewed from before backwards.

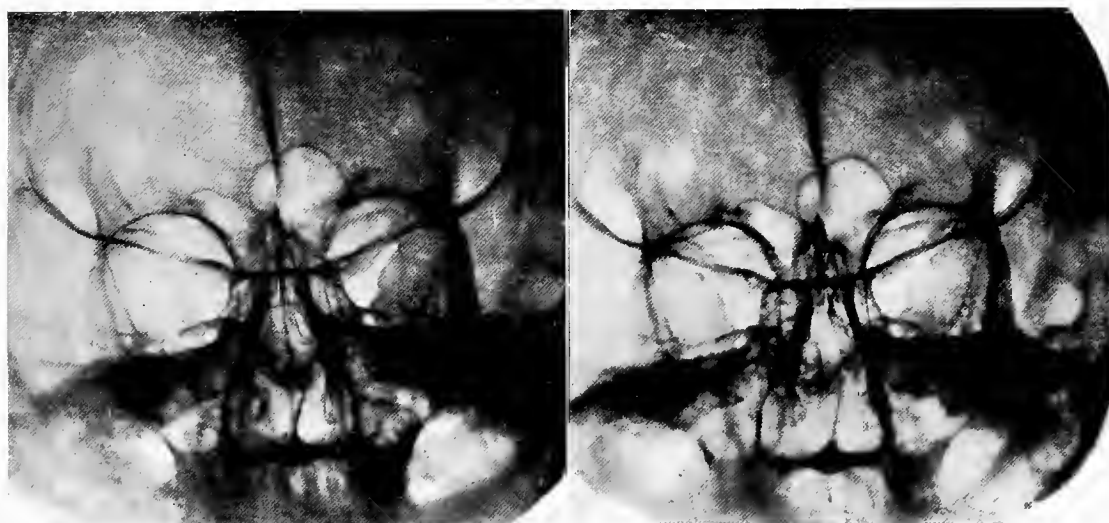


FIG. 2.—The sinuses are viewed from behind forwards.

PLATE III.

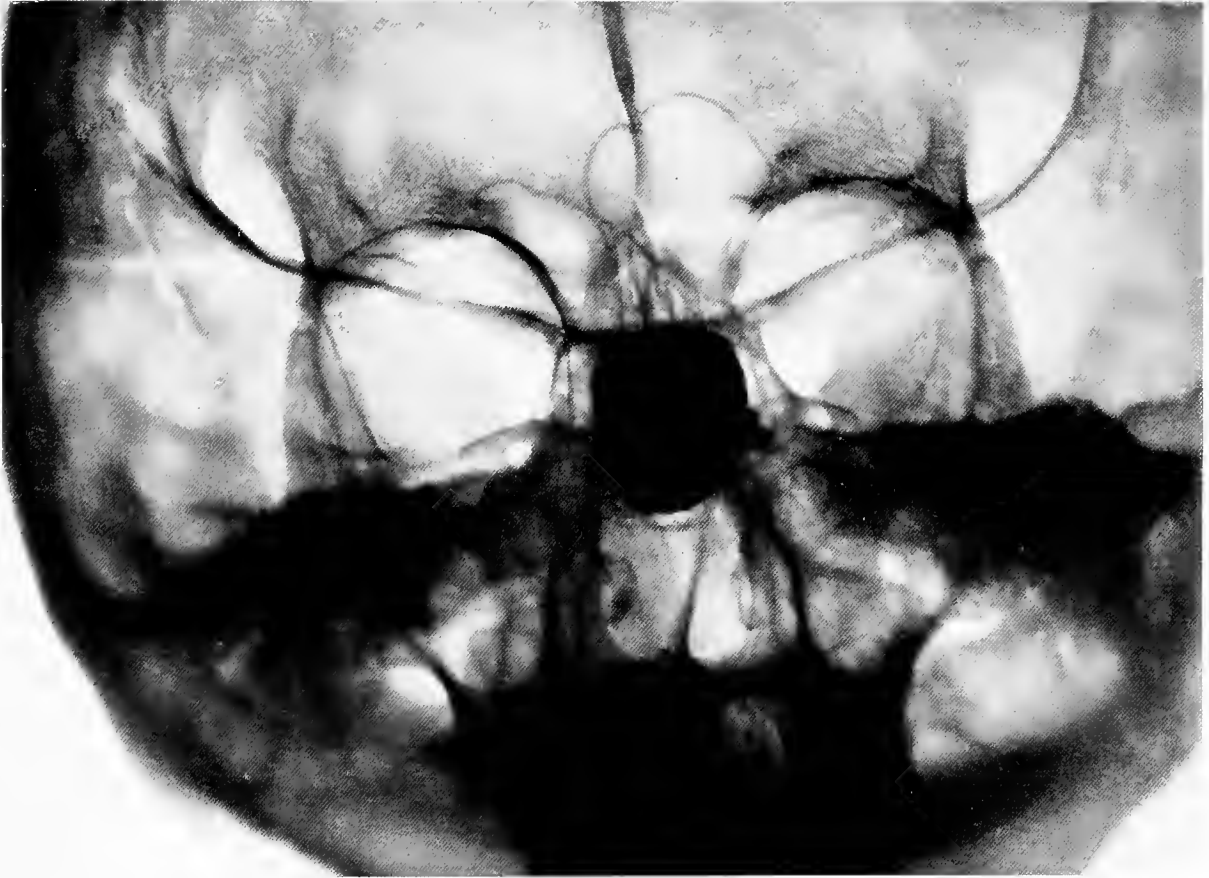


PLATE IV.

Skull of adult, antero-posterior view showing the sphenoidal sinuses filled with bismuth.



PLATE V.

Same skull as on Plate IV., lateral view, showing the sphenoidal sinus in relation to the sella turcica above and to the maxillary sinus below.



PLATE VI.

Same skull as on the two previous Plates, viewed from below : the area representing the sphenoidal sinuses is seen behind the hard palate. The basi-occipital and the foramen magnum lie posterior to the sinuses.

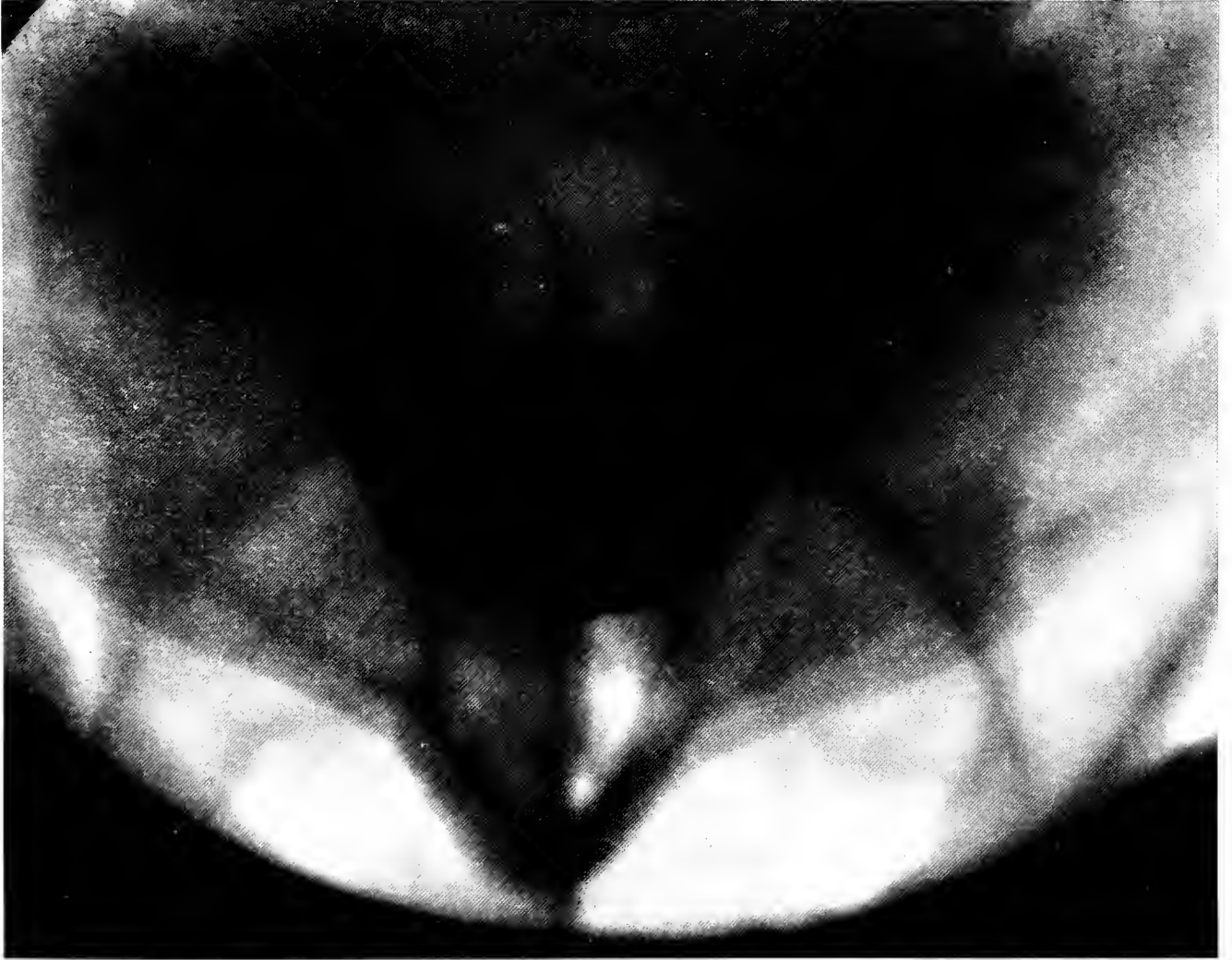


PLATE VII.

Basal view of the head of an adult skiagraphed by Pfeiffer's method ; the two sphenoidal sinuses are seen, the right cavity being larger than the left. The individual is wearing a dental plate on the palate.



PLATE VIII.

Antero-posterior view of adult skull demonstrating malposition owing to tilting upwards of the face. The line representing the lesser wings of the sphenoid bone bisects the orbital cavities and crosses the lower part of the ethmoidal region: the petrous temporals are seen against the lower part of the maxillary sinuses. The floor of the nasal cavities presents an extensive surface from before backwards, instead of a narrow strip.



PLATE 1X.

Skull with large frontal sinuses, in which the anterior wall of the left frontal sinus has been removed. The ethmoidal cells extend into and occupy a large part of the roof of each orbit: the floor of the orbital extension of the ethmoid has been removed upon the left side.



PLATE X.

Head of adult ; antero-posterior view ; the sinuses are normal. The frontal cavities are small ; the ethmoidal cell areas are clear. The right maxillary sinus has an alveolar recess, but this is absent upon the left side. The individual is wearing an upper tooth plate.



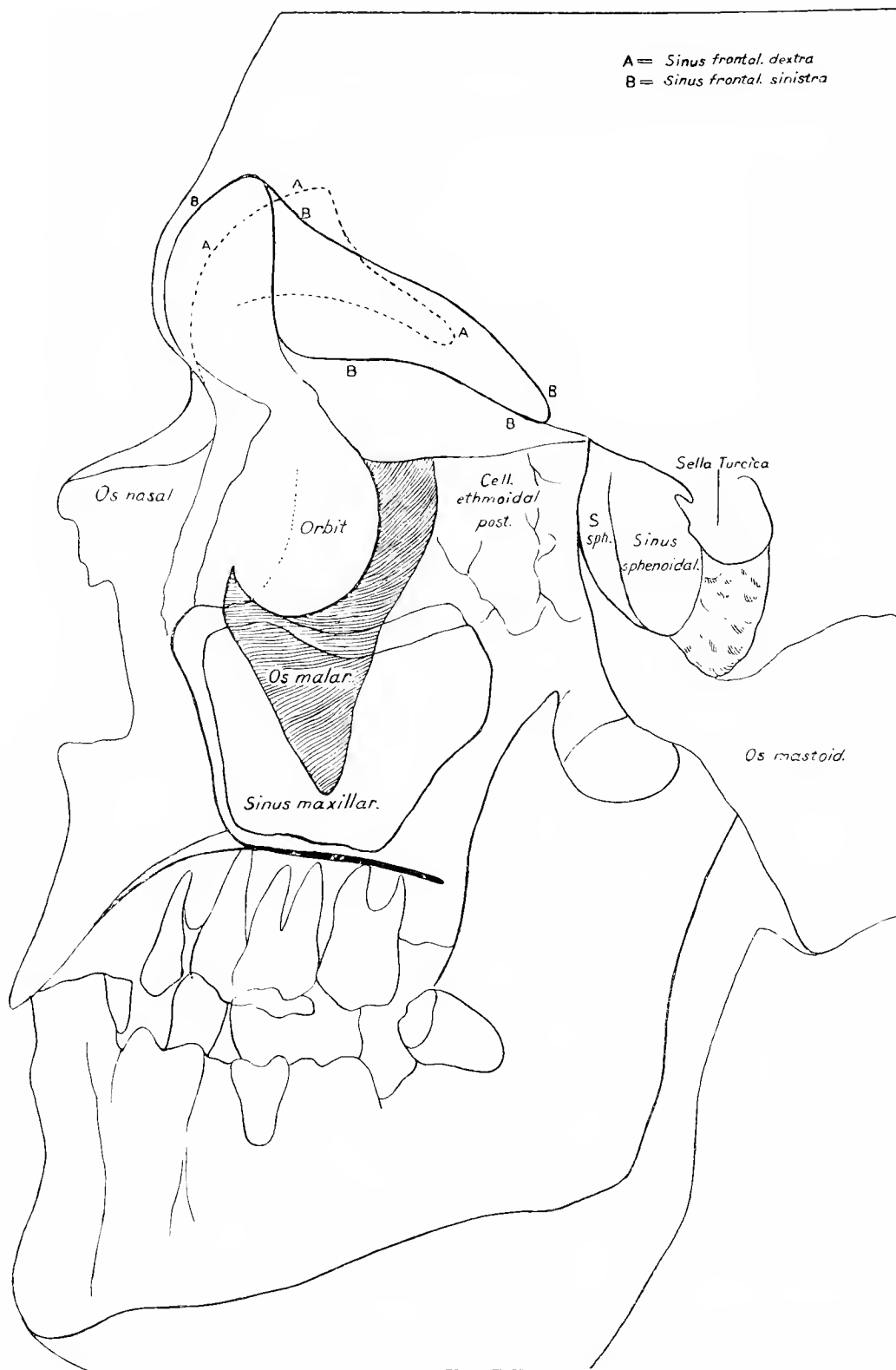
PLATE XL

A reproduction of the negative from which Plate X, was made.



PLATE XII.

Stereoscopic view of head of girl aet. 15. The shadow in the right maxillary sinus is due to a large cystic polypus which passed through the middle meatal wall and presented in the right choana.



Key to face Plate XIII.



PLATE XIII.

Lateral view of adult skull showing the sinuses in profile. Note the great depth of the frontal sinuses and their extension along the roof of the orbit.



PLATE XIV.

Profile view of the skull (left side) reproduced from the negative. The white lines indicating the walls of the frontal sinuses and their orbital extensions are well seen.

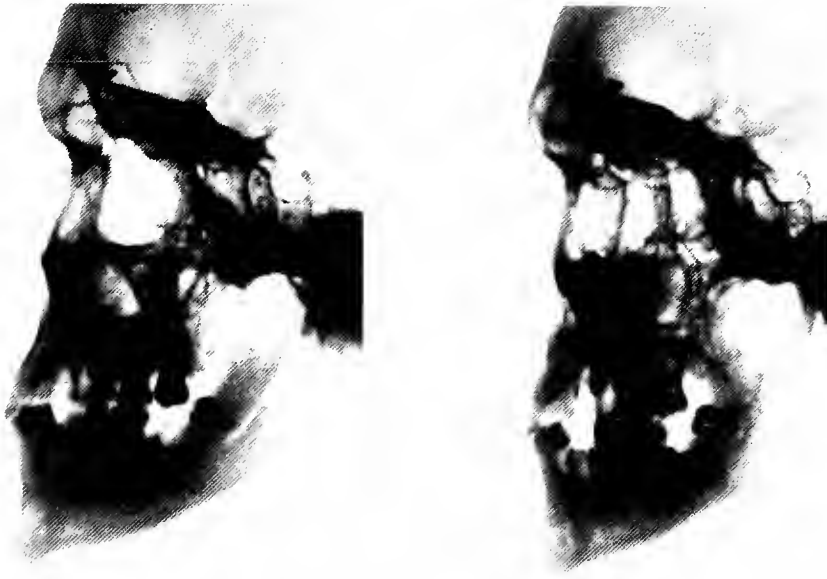
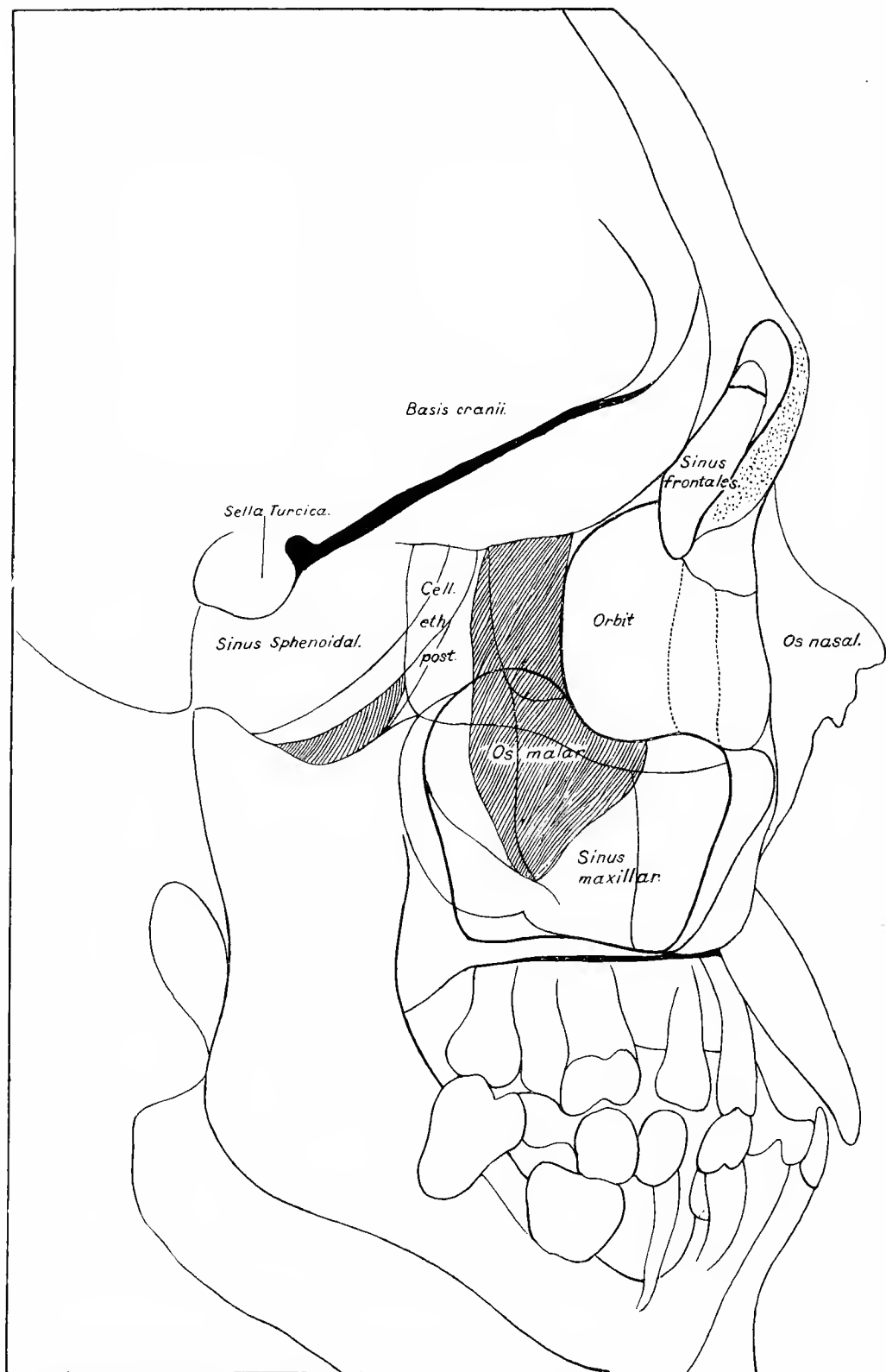


PLATE XV.

Stereoscopic profile view of the skull (left side).



Key to face Plate XVI.



PLATE XVI.

Profile view of normal head of adult (right side).

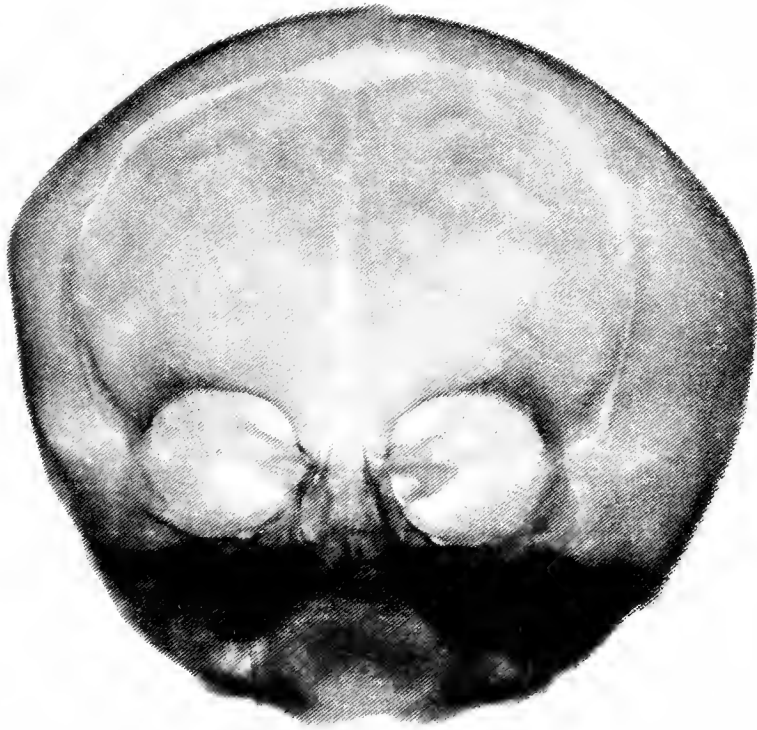


PLATE XVII.

Skull of full-time fetus. The skiagram shows no evidence of maxillary sinuses or ethmoidal air cells, although these cavities are present at birth.



PLATE XVIII.

Skull of child, aged 1 year. The maxillary sinuses are seen as small cavities beneath the inner ends of the infra-orbital margins.



PLATE XIX.

Skull of child, *æt.* 3 to 4. The maxillary sinuses are seen as small triangular cavities beneath the inner third of the infra-orbital margins. They are seen extending outwards as far as the infra-orbital foramina. The ethmoidal cells are seen below the fronto-nasal suture, but there is no evidence of any sinus development in the frontal bone.



PLATE XX.

Head of child, aet. 5. Antero-posterior view, showing well-developed maxillary sinuses. Two small frontal sinuses are seen occupying the lower part of the frontal bone.



PLATE XXI.

Head of child, aet. 5, showing well-developed frontal sinuses.



PLATE XXII.

Head of child, act. 7, showing a small but well-developed left frontal sinus.



PLATE XXIII.

Head of child, aet. 12, showing well-developed frontal sinuses. The narrow clearer area in the lower part of each frontal sinus indicates the extension of the cavity along the roof of the orbit.

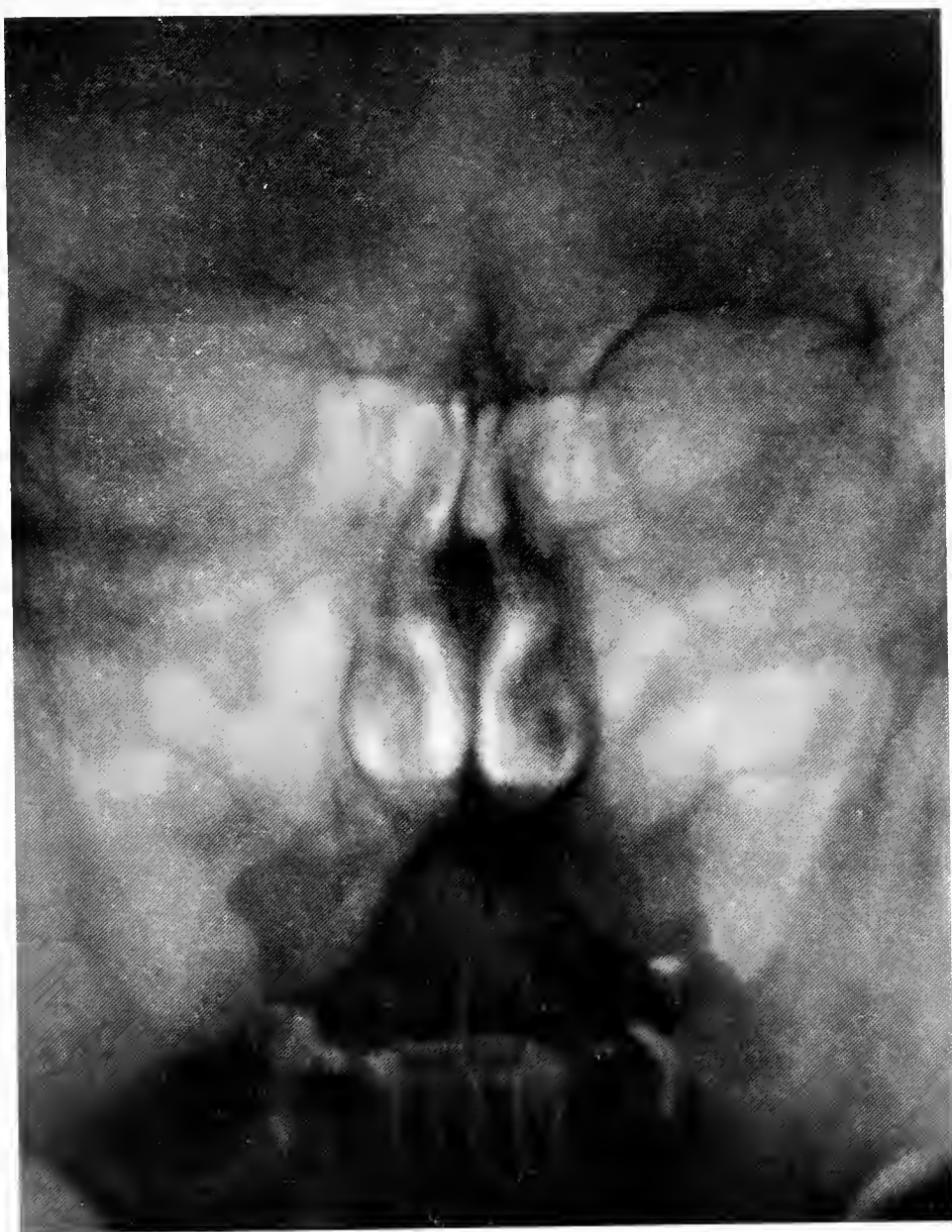


PLATE XXIV.

Well marked V-shaped palate. The septum is perpendicular. The floor of each maxillary sinus lying below the level of the corresponding nasal floor does not extend for any distance into the alveolar process.



PLATE XXV.

Head of young woman, *æt.* 18. The nasal cavities are large transversely. The maxillary sinuses are encroached upon by the bulging outwards of the nasal walls. The frontal sinuses are absent.



PLATE XXVI.

Chronic suppurative in the left frontal, ethmoidal and maxillary sinuses: the deeper shadows upon the affected side present a marked contrast to those upon the healthy right side. The narrow clearer area lying immediately above the right supra-orbital margin depicts the orbital extension of the frontal sinus. A similar extension in the left frontal sinus is also indicated.

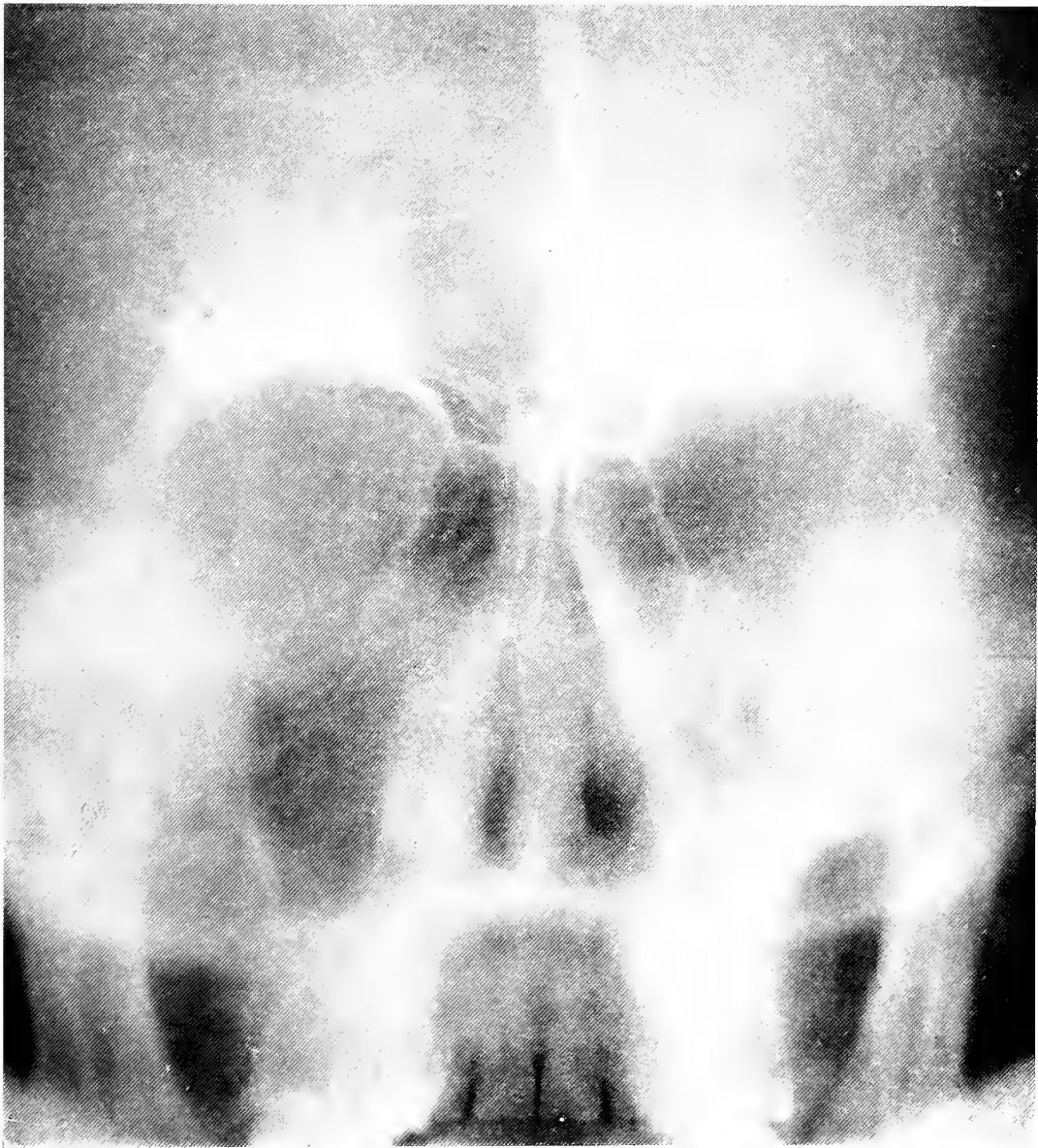


PLATE XXVII.

Reproduction of the negative of the head of a young adult with suppuration in the left frontal, ethmoidal and maxillary sinuses. The skiagram suggests the existence of an air space in the crista galli and a "frontal bulla" in the right frontal sinus.



PLATE XXVIII.

Chronic suppuration in the right maxillary sinus: adult male; a well-developed alveolar recess is seen in the healthy left maxillary sinus.



PLATE XXIX.

Chronic suppuration in both frontal, ethmoidal, sphenoidal and maxillary sinuses: both frontal sinuses show dense shadows and blurred outlines not easily differentiated. The existence of disease in all the sinuses was proved by operation.



PLATE XXX.

Patient with bilateral fetid atrophic rhinitis (ozæna): the roomy character of the nasal cavities with the atrophied middle and lower turbinated bodies is well represented. Although the shadow of the left maxillary sinus when compared with that of the right side suggests suppuration, proof puncture of the cavity gave a negative result.



PLATE XXXI.

Mucocele of the right frontal sinus: there is no left frontal sinus. The nasal septum is considerably deflected to the right: the hard palate is flat. The sinus area is brighter than that usually observed in a healthy frontal sinus owing to the absorption of the posterior or cerebral wall of the sinus.



PLATE XXXII.

Mucocele of the right frontal sinus which had recently become infected with pyogenic organisms. Suppuration has also occurred in the right ethmoidal and maxillary sinuses.



PLATE XXXIII.

Patient with a dental cyst invading the right maxillary sinus. The cyst, which contained milky, sticky fluid, is seen as a dark shadow in the lower and inner part of the right antral area. The upper and outer parts of the antral cavity are not occupied by the cyst, and present a clearer area. The X-ray appearances were confirmed by operation.



PLATE XXXIV.

Patient with a naso-antral (cheanal) polypus on the left side. In all the cases of this affection which were submitted to the X-rays the affected maxillary sinus showed a deeper shadow than the healthy sinus. The same cases when examined by transillumination showed the affected cavity to be brighter than the healthy one on the previous page.



PLATE XXXV.

Adult female with a naso-antral polypus on the left side and with chronic suppuration in the right maxillary sinus. A well-marked palatal recess is seen in each maxillary sinus.



PLATE XXXVI.

Patient with a malignant tumour involving the right nasal cavity, right maxillary sinus, ethmoidal cells and orbit. At the operation the tumour was found to invade the orbital plate of the frontal bone on the right side.



PLATE XXXVII.

Profile view of head of adult female upon whom operation had been performed for malignant disease of the right upper jaw.
Recurrence of the disease is evident in the posterior ethmoidal and sphenoidal sinuses.

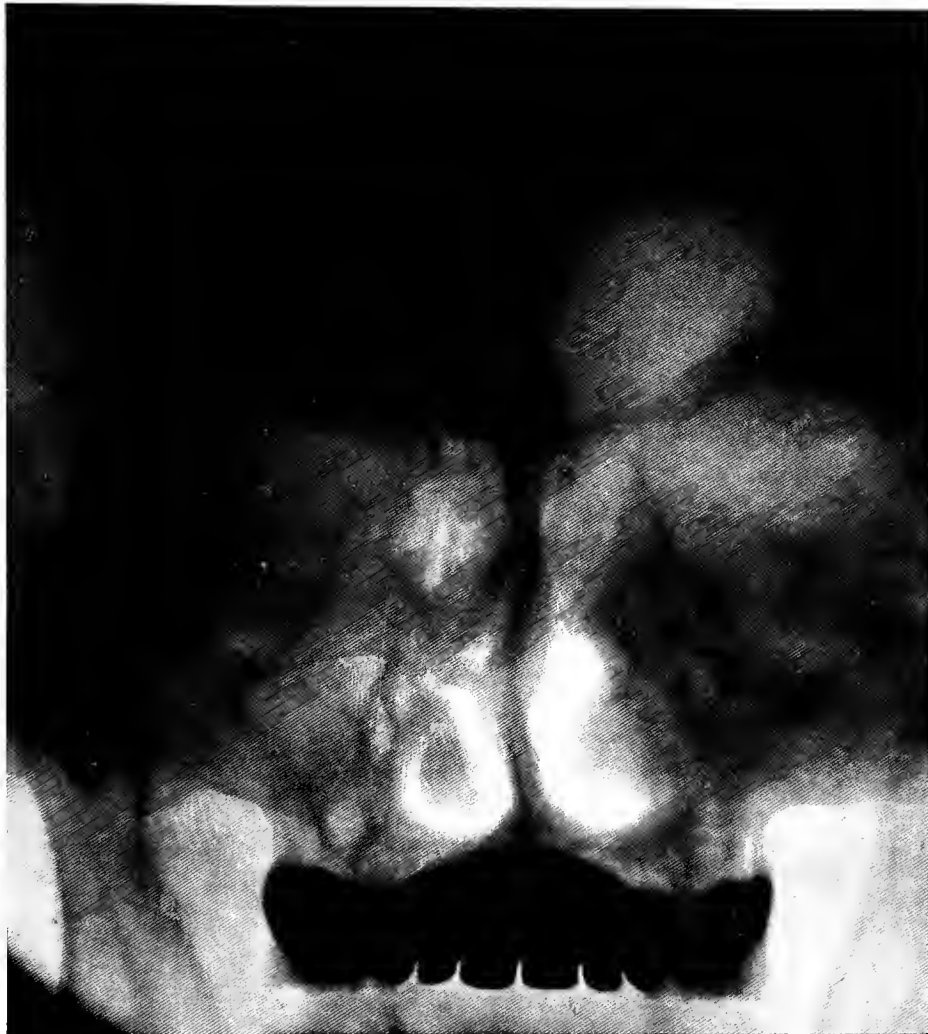


PLATE XXXVIII.

Patient after the Killian operation upon the left frontal sinus. The accentuated brightness of the frontal sinus area operated upon is due to the removal of the anterior bony wall of the cavity. The supra-orbital margin or "bridge" is evident.

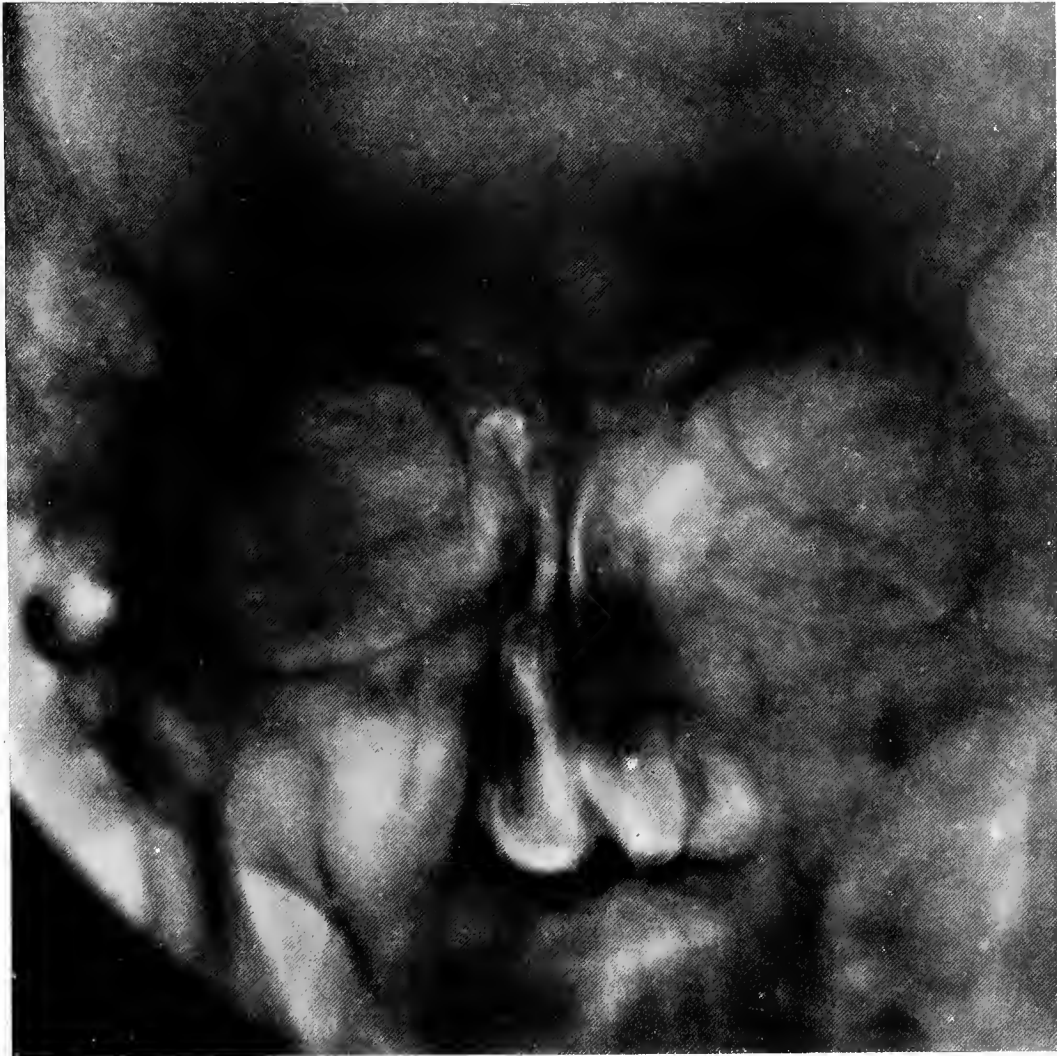


PLATE XXXIX.

Patient after a radical operation upon the left maxillary sinus in which the lining mucous membrane was removed. The small clear area immediately external to the outer wall of the inferior meatus of the nose represents what remains of the cavity of the sinus. The anterior end of the left inferior turbinate body has been removed.

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